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Materials & Methods®

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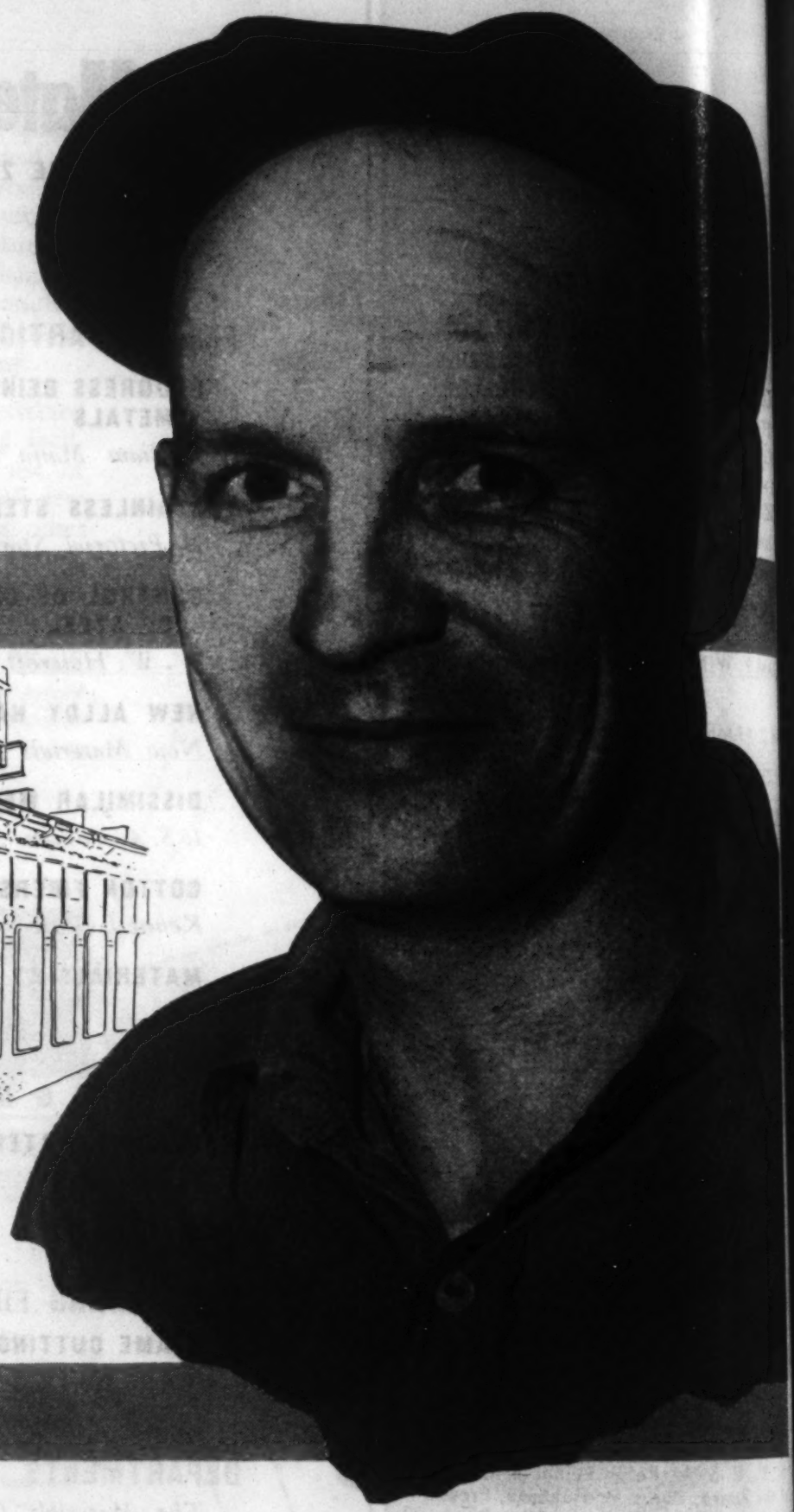

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The MATERIALS OUTLOOK...

MATERIALS PRICES CHANGE, MOSTLY UPWARDS—The last month has seen considerable action in the metal markets, with most prices advancing. Steel was raised by from $3 to $10 a ton immediately after wages were increased, but already a few companies have revised their quotations downward. This may mean the start of a competitive move on the part of mills located some distance from their major markets. Among other base metals which have risen are nickel, lead, zinc, platinum and iridium.

Other materials of interest to the metalworking industries which have been jumped in price are metallic sodium, sodium cyanide and trichlorethylene.

Reversing the trend somewhat are Monsanto Chemical Co. with a reduction in price on Lustrex (polystyrene molding material) and Edwal Laboratories, Inc., which has dropped the price of sodium cyanate.

COPPER TO GO UP--As this is being written the pressure to push copper prices 2c per lb. to 23½c is making itself felt. A few sales have already been made at that price, but most major producers are out of the market until a general price increase has been made. This price could drop just as easily in the near future if government buying for stockpiling purposes were to be abandoned or suspended.

NEW INDUSTRIAL DEMAND FOR GERMANIUM—The Bell Telephone Laboratories recently demonstrated the "transistor" which it is expected will do away eventually with vacuum tubes in radio, television and other electronic applications. The key metal is a speck of germanium soldered to a base and contacted by two "cat's whiskers," or hair wires. The world may start searching in earnest for germanium whose sole producer in the United States is the Eagle Picher Co., as a by-product of lead and zinc. Its previous use has been in medicine. Germanium is a greyish-white metal, with specific gravity of 5.46 and melting point of 1650 F. It sells at 50c per gram in lots of 1000 grams or more. It is presumed that as demand increases a greater mass production and lower prices will ensue. It is sold in three forms: Metal, dioxide and tetrafluoride. It is always possible, of course, that a substitute for germanium may develop. For instance the Navy has adapted a nickel and iron alloy from the Germans to do away with vacuum tubes in amplifiers and to effect far-reaching changes in rectifiers.

STAINLESS STEEL USES INCREASE—Stainless steel has remained relatively plentiful while carbon steel is extremely scarce. Industry is accordingly using stainless as never before. Thus in the stove and range industry the experts say the strongest trend is towards stainless steel, some range makers using over 25 separate parts of this material. Automobile makers are starting to use stainless for tire, or wheel, walls (in place of white plastics) as well as hub caps.

CRYSTAL-CLEAR PLASTICS—Another step forward has been made in bringing out plastic with optical clarity, valuable for several purposes. The Tennessee Eastman Corp. announces Tenite II (cellulose acetate butyrate) to broaden applications. Color matches will henceforth be

(Continued on page 4)

The Materials Outlook *(Continued)*

more accurate, with greater uniformity from lot to lot.

STEEL IMPORTATIONS INCREASING—In normal times considerable iron and steel is imported from Europe. We recall an up-State New York city having bought their entire requirements of cast iron pipe from Belgium for connecting their city with a new reservoir 20 miles away. The first signs of such normalcy returning are at hand. A Weehawken, N. J., maker of water tanks has started to buy black sheet from Belgium, even though priced two and a half times the American price. He can't get U. S. steel, having no pre-war "history." Austria is offering us pig iron, shipped from Trieste, Italy, priced at $82.50 per ton, that port (around $45 for U. S. iron).

RHODIUM A PRACTICAL FINISH—Many finishes demanding a high quality surface on end products are turning to rhodium of the "platinum group," which possesses greater whiteness and reflectivity than platinum and palladium. It is chemically-inert and extremely hard and heat-resistant. Though rare and costly, the efficiency of a very thin coating makes it competitive. A watch maker uses it to combat condensation by changes in temperature and humidity. It is used on electro-formed nickel reflectors; on a spherical reflector to shine investment ticket quotations and news bulletins on a trans-lux screen; on a mirror with a rhodium reflective surface on the front of the glass to eliminate double image and refraction errors; as a plate on copper wire for "catwhisker" contacts in electronic hook-ups.

NEW MAGNETIC ALLOY—Details of a new magnetic alloy, which the Naval Ordnance Laboratory has called Permenorm 5000-Z, can now be revealed. Practically all of the magnetic and electrical core materials of recent years have been complex alloys. But this alloy is a simple one of 50% nickel and 50% iron. The complexity is in the working and heat treatment to obtain proper structure. The Germans had the idea first in 1943, but they failed to get it past the preliminary laboratory stages. The alloy is given a drastic cold rolling in one direction. Then follows a special heat treatment which is not merely for annealing, but it assures that the chemically combined iron and nickel give a grain orientation in one direction. Magnets made from the material are machined to have the proposed north and south poles in the direction of the structure. When placed in a magnetic field the grains polarize instantly all in the same direction, producing a square hysteresis loop for the whole magnet, hitherto impossible to obtain. The increased efficiency of the alloy will reduce drastically the size and weight for large installations of magnets and cores. The alloy is also strong and shock resistant. It can also rectify an electric current at fully saturated density, and it will make a superior magnetic amplifier to replace some hitherto flimsy types of vacuum tubes. The Naval Ordnance Laboratory has developed a manufacturing process to make practical and simple the commercial production of the material.

GROWTH-RESISTANT CAST IRON—Battelle Memorial Institute has just announced a new cast iron which is ideally suited for applications where high temperatures (up to 1700 F) are involved. Outstanding feature of the new iron is its ability to resist growth at elevated temperatures. Basis of the new material is a high-silicon iron. During the casting process, minor amounts of copper and chromium are added to resist scaling at high temperatures. Uses anticipated for the material include castings for cooking stoves, heating stoves, home furnaces, melting pots, gas and oil burners, heat treating containers of various kinds and many types of industrial equipment.

AN EDITORIAL

Materials Engineering and Design

We were going to head this editorial "Is Shape Important to Materials Engineers?" and then decided it might be construed as another abbreviated Kinsey Report. The answer in the technical sense (and doubtless also in the biological) is definitely "yes," for the relation between the geometry of a product and the materials of which it is made is close, and designers and materials engineers are increasingly coming to recognize the relationship.

In a recent talk Paul Ffield of Bethlehem's Shipbuilding Division defined materials engineering simply as "tailoring the materials to the job, or vice-versa." A "job" has many aspects in addition to its physical property requirements—shape, location, availability or kind of fabricating and processing facilities, costs budget, etc. The materials engineer must have all these in mind when selecting and specifying his materials. To a steadily increasing extent he is exerting his influence on these other factors—i.e., he is succeeding in arranging for redesign or for changes in process procedures—especially where they limit his materials choice to a generally unsound selection.

We have tended to think of the processing problem as being the one most closely related to materials selection. Ffield, while not belittling processing, points to shape factors as making the difference in a large number of cases between good materials choice and a good final product on one hand, and poor materials selection and eventual performance failure, on the other.

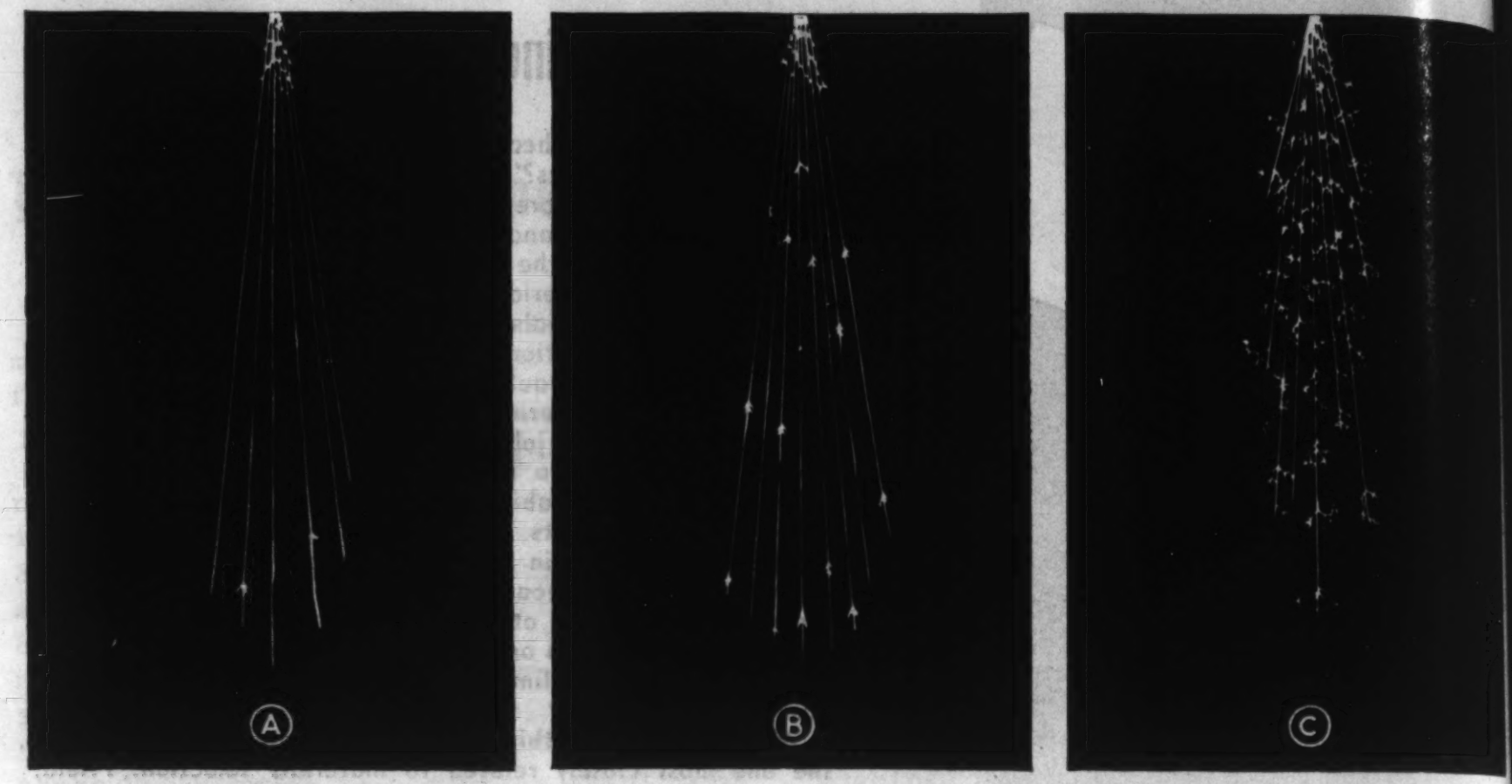
We have had a demonstration of this on a colossal scale in the case of the fractured Liberty ships. Exhaustive tests to determine whether the materials used or the fabricating methods (welding) or the design were the cause of these failures showed that the basic cause of failure was the presence in the overall design of excessive restraint and of "notches"; failure was especially likely to occur when steels of inferior impact properties and faulty welding practice were employed. For the solution of this problem *both* materials engineers and designers had to learn the other fellow's business as well as their own, and to carry out their assignments with one eye on the other factors present in the job as a whole.

Many of the "properties of materials" which we consider characteristic of certain materials, Ffield believes, are actually characteristic of the shapes in which we customarily use them. For example the reputation that castings have for being mechanically inferior to wrought metals is not justified on the basis of tests made on similar simple shapes of both materials. It just may be that castings, being more amenable to production in intricate shapes, are most frequently loaded with the notches and areas of stress concentration that accompany such designs; in the last analysis it may be these design weaknesses that are the cause of failure rather than alleged inferiority in the material or production method.

Spring steel and file steel are not greatly different materials. But after they have been tailored to the product in each case through specific design and processing, the end products are then so different in general characteristics and behavior as to appear to be made of different materials.

Designers and materials engineers can both profit, with immeasurable benefit to industry as a whole, by a better understanding of the other fellow's objectives and problems. "What the Design Engineer Should Know about Materials" and "What the Materials Engineer Should Know About Design" could fill two books, and they ought to be in every engineering library.

FRED P. PETERS



Mark your answers here. Carbon content of steel A. is ___% B. is ___% C. is ___% Correct spark readings are given at lower left

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Materials & Methods
AUGUST 1948

For applications where corrosive conditions are anticipated, clad steels are being widely used. Here a clad metal "sandwich" is ready to be rolled.

Progress Being Made in Fight Against Corrosion Losses of Metals

by **WILLIAM MANN**

IN GENERAL TERMS, CORROSION can be considered the cancer of modern industry. The destructive effects of corrosion on industrial equipment and on engineering structures of metal and other materials have many points of analogy with the insidious creeping action of cancer on living tissues. In fact, the word "korrosion" is used as a medical term in certain European languages to signify the destruction of bodily tissues or parts of organs by an "etching action." A German doctor, for example, is likely to tell a patient that his peptic ulcer is the result of "korrosion" of the stomach wall.

Depletion of natural resources and higher costs of products spur efforts to fight corrosion through better materials and better finishes.

Skin cancers can be likened to surface corrosion, and such superficial attacks are the easiest kind to detect and remedy. Again, there are the deep-lying forms of internal cancer which are analogous to the insidious type of corrosion which does its destructive work below the surface of a metal and gives no sign above that deep decay is at work and that untimely failure will result. But this analogy with the internal decay of organic materials must not be drawn too closely. Although a cursory examination of a metal

Where appearance and durability are wanted, stainless steel is often used because it requires no further finishing.

with the eye may lead one to think the surface is perfect, a closer examination with the aid of a microscope often reveals a great many tell-tale cracks which indicate that a slight loosening of the surface is under way and that trouble below is in course of development. In addition to their other disadvantages, both cancer and corrosion place enormous and largely-uncompensated economic burdens on society.

For many years metallurgists have taken a serious view of the general corrosion problem and of its ultimate effect on our economy. A number of impressive factors are now also forcing laggard industrial management and the general public to take an interest in the various methods of combating corrosion that have long been proposed by students of this problem.

First among these factors is the truly colossal cost of corrosion. Replacements, shut-downs, and the labor cost of new installations are estimated by experts to soar into billions of dollars annually. We will not venture to give a definite figure to represent the cost of this burden, which must in effect be a mere guess at a minimum. It is known, however, that high cost alone is not likely to deter many men from habitual patterns of behavior. We can see that in the expensive, hoary, and universally-accepted institution of economic war. Nevertheless, the extreme tax that corrosion places on our economy is impressive as a subsidiary impetus to action.

Second, there is the growing certainty that corrosion is rapidly depleting our supply of certain high grade ores. We will not venture to say how long present supplies will last, or to discuss the complicated relation of that supply to the supply of scrap. But here again it strikes the vulnerable pocketbook of stockholders, who are already suffering from low profit margins, another severe blow in a very sensitive spot. It costs more money to work poor ores, and the resultant more expensive materials make manufacturers, architects, and engineers increasingly reluctant to design structures with exceptionally heavy safety factors to allow for anticipated corrosion.

Third, there is the plain fact that we expect more from our metals than we used to. The extremely heavy duties placed upon them in new applications like gas turbines, jet engines, and in certain chemical manufacturing problems at high temperature and pressure bring one face-to-face with the corrosion problem in new and difficult ways. New products of especially aggressive natures such as fluorine, and the continued demand for purer old products bring corrosion into even sharper focus. The penalty for neglect is direct and prompt. It is not possible in these new applications for the engineer to follow tradition in specifying materials. Often there is no tradition. The engineer who was content in the old days to ignore the service-life of the structure he designed would now be trifling with consequences of the most serious kind.

Any one of these factors can probably be shown to have an economic basis, and while one economic difficulty alone may not be enough to stir men to action, all of them together may do so. In addition, during the last war many men saw for themselves what corrosion in bad climates swiftly does to equipment on which their lives depend. Not a few of these veterans will ultimately land in places where their influence will count. And this personal evidence of corrosion danger may impress them even more than a dollar mark with a long row of zeros after it to represent the annual cost of it to the community.

Whatever the causes, there are many signs of increased realization that a united effort is needed to attack a phenomenon which continually strikes our economy so widely and so hard. One can point to such significant recent developments in the United States as the founding of the National Association of Corrosion Engineers and the rapid growth of this vigorous young society. Last year a widely-attended International Conference on Corrosion was held in Paris, similar to the international congresses regularly held to discuss progress in cancer research. This year saw the issuance of the "Corrosion Handbook" by the Electrochemical Society. This book of over 1200 pages is a comprehensive cooperative effort that is unique in this field and one that meets a very special need in disseminating the information already available.

This brings us to an important point, one that is too often overlooked. The corrosion problem is still serious, but it would be a mistake to conclude from what has been said about this seriousness that little or nothing has been done already. Much that is of the utmost value in both fundamental and applied research has resulted from studies undertaken by research organizations, private and governmental, and by certain leading manufacturers. Corrosion losses, great as they are, would undoubtedly be much greater if it were not for the efforts of these agencies during

the last few decades. But the subject is complex, much of the data are scattered or were until recently, and a considerable job of fundamental research and coordination remains to be done.

The writer is in a position to know how much good work has been done by many leading manufacturers of corrosion-resistant metals. Let no cynical observer thoughtlessly minimize this important contribution. It is to the interest of these manufacturers to disseminate accurate and carefully-qualified information concerning the limitations as well as the virtues of their various products. The writer is inclined to look with favor on commercial information that is in the direction of enlightened self-interest; it is a sort of commercial compound of lower free energy toward which sound business intelligence moves spontaneously. For instance, it is in the interest of life insurance companies to keep the premium payers alive, and one may therefore accept their health statistics and advice about longevity with considerable confidence. Similarly, it is in the interest of metal producers to keep their metals alive as long as possible and not to favor a short-lived installation that would in short order be an obvious detriment to continued business.

The "Cause" of Corrosion

There is a rather wide-spread belief among laymen that certain ancient metals and alloys were capable of miracles of corrosion resistance and that the knowledge of how to produce such materials has been lost. The evidence for such beliefs is generally traced to a number of iron pillars that have survived in the hot dry rural atmosphere of India for many centuries. These remarkable examples of metallurgical longevity really do exist, but it has been shown that they rust promptly when exposed in a moist environment in England. The fact is that metallurgists have never known so much about corrosion and the art of producing resistant materials as they do today. Especially great strides have been made in their field during the last half century.

One of the classic papers in this field, which has been reprinted a number of times because of its basic importance, is the one in which Dr. W. R. Whitney first described the corrosion of iron in generalized electrochemical terms. For this valuable contribution Dr. Whitney was the first recipient of the *Willis Rodney Whitney Award in the Science of Corrosion* that was established in his honor last year. by the National Association of Corrosion Engineers. We do not have space here to consider many of the very interesting older theories of corrosion which have now been discarded. In their day each of them successfully explained one or more of the limited phenomena studied by that particular author, and all had their respective protagonists. So many factors associated with a metal and with its environment can exert a measurable influence on corrosion reactions that a multiplicity of hypotheses is favored. The theory of corrosion that has not only shown the greatest power of survival, but has successfully explained corrosion phenomena in the most general terms and has gone from strength to strength as additional evidence has come in from other departments of science, is the electrochemical theory. On this account it has earned almost universal acceptance by metallurgical scientists. There are many elements that obviously influence the course of corrosion reactions; notably oxygen in air, in water, and in acids; carbonic acid is apparently a basic offender in other cases; and sulfur is quite often destructive, especially when combined with oxygen in gases and acids. The electrochemical phenomena at the bottom of such corrosion reactions may operate through the intervention of acids, colloids, peroxides, oxygen and even certain bacteria, but the electrochemical phenomena that take place when a metal enters solution is common to them all, and interpretation in these terms has therefore, in the course of time, superceded all the more limited theories that once were popular.

Elementary Electrochemical Principles

The basic principles of electrochemical corrosion

The advance in rust-proofing materials has added considerably to the life of steel products. Here steel parts are being given a phosphate treatment.

stated by Dr. Whitney in 1903, and greatly amplified by many other investigators ever since, are simple in themselves. The many complications of corrosion phenomena that exist in practice arise from the fact that the conditions faced in practice vary with every different physical and chemical requirement imposed by industry on metals. As iron is the most common structural metal, and is the one used in Dr. Whitney's pioneer study, we will use this metal for our brief discussion of electrochemical corrosion principles; but it must be understood that the phenomena described are general for all metals.

When placed in water or in certain other conducting liquids, iron possesses a definite and measurable tendency to go into solution as ions. This is only an initial tendency until conditions are set up to make it possible for this tendency to be exercised. Metallic ions are electrically positive, and if they are to continue to dissolve without spontaneously imposing a finite charge on the solution, an equivalent number of other positive ions must be removed from the solution. In this respect hydrogen is capable of acting as a metal. This actually happens. Hydrogen derived from decomposed water immediately plates out on the surface of the iron as an exceedingly thin film and keeps the system electrically neutral. This film is of the utmost importance, and under proper conditions it can be the contolling factor in stopping further corrosion. It often operates in two ways. It protects the iron from further attack by insulation, and also, the electrical tendency of the hydrogen film is to re-enter solution and oppose further corrosion.

Any effect tending to destroy this hydrogen film is corrosive in its nature and this is how the real trouble now often begins. The hydrogen film is destroyed when it continuously bubbles off as a gas (as it does from an acid solution), or it may combine with oxygen present in the solution and thus be effectively removed (as it is in a well-aerated solution). A widely-practiced application of this principle is the deaeration of water to reduce corrosion in boilers.

Certain alloys, especially those containing chromium, become passive in the presence of any one of a large number of oxidizing environments and behave as if they were nobler than one might expect from their place in the electrochemical series. This gives them a very high degree of resistance to oxidizing acids, which is believed to be due to a tight and protective coating of oxide film, or an adsorbed gas layer. This film is also self-healing under many acidic conditions. But for most commercial metallic materials, solutions with a pH below about 4.3 cause rapid corrosion because they are strongly acidic. Solutions that are strongly alkaline, with a pH above 10, cause mild corrosion except in the case of aluminum and other amphoteric metals which may be attacked severely by certain alkaline solutions. The presence of oxygen is of major importance in corrosion by solutions with intermediate pH values.

To return to our original example, when iron corrodes in an aerated aqueous solution due to its solution pressure, it is soon oxidized and precipitated as rust. This ordinarily permits more iron to dissolve, thus intensifying corrosion; but sometimes, if conditions are right, the rust will deposit as a protective layer on the metal and lessen corrosion. Corrosion is also decreased in circumstances where the supply of oxygen can be exhausted, as in certain sealed apparatus.

When rusting occurs on metals exposed to the atmosphere, the extent of subsequent corrosion depends to a great extent on the initial surface condition and the character of the first layer of corrosion products that is formed. Under exceptionally favorable conditions, as in the very ancient Indian irons mentioned above, or in properly constituted alloy steels in more corrosive atmospheres, the initial oxide forms as a thin and very adherent coating which may resist further attack for years.

Protective Methods

Up until a few years ago metallurgists seriously considered only two methods of restraining a metal from its inherent tendency to revert to its common ore, generally an oxide, or to other compounds of lower free energy. One method was to coat over the surface so that corrosive media could not reach it; and the other was to depend on alloying the metal with large amounts of a protective film-forming constituent. These two methods are still among the most important general protective measures, and perhaps they still are most fundamental; but they have in recent years undergone many improving developments and have been joined by a number of new

High strength, low alloy steels offer a means of keeping corrosion under control in many types of equipment such as tractors and earth movers.

techniques. Let us briefly run over the main features of these recent developments in corrosion control.

There are a number of metals that possess natural advantages with respect to resistance against certain types of corrosive attack. And certain of these have been greatly improved in their resistance by being prepared in a nearly pure condition. But when a metal that does not possess such natural advantages is available in commercial quantities at an attractive price, it is common practice to improve its properties by alloying it with other metals. This is one of the oldest and most effective methods of improving chemical and physical properties. Such benefits are commonly ascribed to the presence of a thin, continuous, and protective film of metal oxide. This view is widely-accepted and is backed by considerable experimental evidence, but it is not accepted by all students of corrosion. Some investigators attribute the passivity of resistant alloys primarily to the effects of an adsorbed film of oxygen atoms, often augmented by an oxide coating. Alloys containing chromium have also done particularly good work in reducing corrosion at high temperatures. Other alloying elements that are important for this purpose are nickel, aluminum, cobalt and silicon. This branch of corrosion phenomena, *i.e.* at high temperatures, has also been explained by some investigators in electrochemical terms.

The principle of cathodic protection has received wide acceptance in recent years for the preservation of iron pipelines and other buried structures. It is one of the many practical proofs of the electrochemical theory that would be difficult to explain in any other way. In this method the electrical current needed to neutralize the current which causes the corrosion is supplied by sacrificial anodes of light metals of high electrochemical equivalent or by an external anode connected to a suitable source of direct current. Once the proper amount of current necessary for neutralization has been established by test, the protection that can be afforded by this means under favorable circumstances is practically complete.

Coatings of sacrificial metals in general may also be considered instances of cathodic protection. When a steel surface is galvanized it will not rust so long as zinc remains to be corroded. The extent of the protection that can be expected around a break in the zinc coating depends upon the size of the break and on the corroding medium. Owing to its position in the electrochemical series and its light weight, magnesium has certain natural advantages in the field of cathodic protection. The light metals have profited in increased corrosion resistance both from greater purity and from careful alloying.

The addition of chromium, nickel, molybdenum, manganese, silicon, columbium, tatantium and certain other constituents definitely confers desirable properties on a number of other commercial metals. The stainless steels are noted for their "passivity" with respect to strongly corrosive substances such as nitric acid and many others. Nickel has outstanding resistance to caustic soda and other alkaline substances, and the addition of this metal confers such virtues on many alloys.

Years of added life are given valves by making them of stainless steel castings.

The use of paints and lacquers is so common as a protective measure that one is prone to overlook its importance. In fact, interesting speculations about the cost of corrosion have been based on the amount of paint used per year to protect iron structures. Organic coatings that resist alkalies are valuable for use in combination with cathodic protection, as alkalies are produced at the cathodes in such work. These organic coatings are electrically insulating. The neutralizing current therefore flows only to a break in the coating, and this fact plays an important role in effective distribution of the current needed to protect the vulnerable areas to best advantage.

A growing number of miscellaneous processes are used to diminish corrosion by changing the corrosive environment rather than the metal itself. Among them is the common practice of reducing dissolved oxygen in water by the use of deaerators. These machines function by spraying the water into a vacuum chamber and removing the dissolved gases at moderate temperatures. This process also lowers the carbon dioxide content of the water, which is a factor of considerable importance in diminishing the corrosion of high pressure boilers. In low pressure boilers carbon dioxide can often be safely reduced by the addition of lime. And many other substances are in common use for reducing the corrosion rate in boilers. Inhibitors are also of importance where it is practical to use them. These materials are regular constituents of certain paint primers.

In discussing these recent advances, we have had to be brief to fit the space at our disposal. We have, perhaps, done no more than indicate that an excellent beginning has been made in the fight against corrosion. On the whole, it seems to the author that research in this field, although often only grudgingly financed as a necessary negative evil, can point to results that are just as valuable to society as any of its more positive sister sciences.

1 *Two pre-sheared half circles or two rectangular 18:8 stainless steel sheets are joined together by automatic Heliarc welding in preparation for spinning.*

2 *If rectangular sheets are used they are sheared to the proper diameter after welding. Before the spinning operation, the weld is ground smooth so as not to interfere with the forming tool.*

Large Stainless Steel Tank Heads Fabricated by Spinning

A PICTORIAL STORY

Forming stainless steel by deep drawing and stamping methods where large sizes or a variety of sizes are involved is frequently impractical because of high die costs. In these cases spinning often offers a more practical solution. One such case is the successful spinning of large 18:8 stainless steel tank heads on a production basis by the Milwaukee Metal Spinning Co.

These heads or ends are used in milk storage tanks and range from 36 to 102 in. in dia. The stainless steel is of the regular Type 305, containing 18 chromium and 8% nickel.

Since standard widths of stainless steel sheet are more readily available and more easily shipped and handled, the blanks for spinning are made up of two sheets welded together by the inert gas shielded arc process. The weld is then ground flush so as not to interfere with the spinning operation. The sheets are sheared to size either before or after welding.

The method of spinning differs in some ways from ordinary spinning operations in which the blank is clamped in the center and is worked from the center out to the edge over a convex block. However, in spinning these stainless steel heads, the blank is clamped around its circumference. As the blank spins, a steel roller, mounted in a lubricating compound, revolves in direct contract with the metal. This roller, as it pushes in against the metal, moves from the center out to the edge of the blank, thus forming the head to the desired shape. An earlier method involved spinning by hand and required three men. This method is now obsolete, having been replaced by the roller type machine which spins mechanically and needs only one operator.

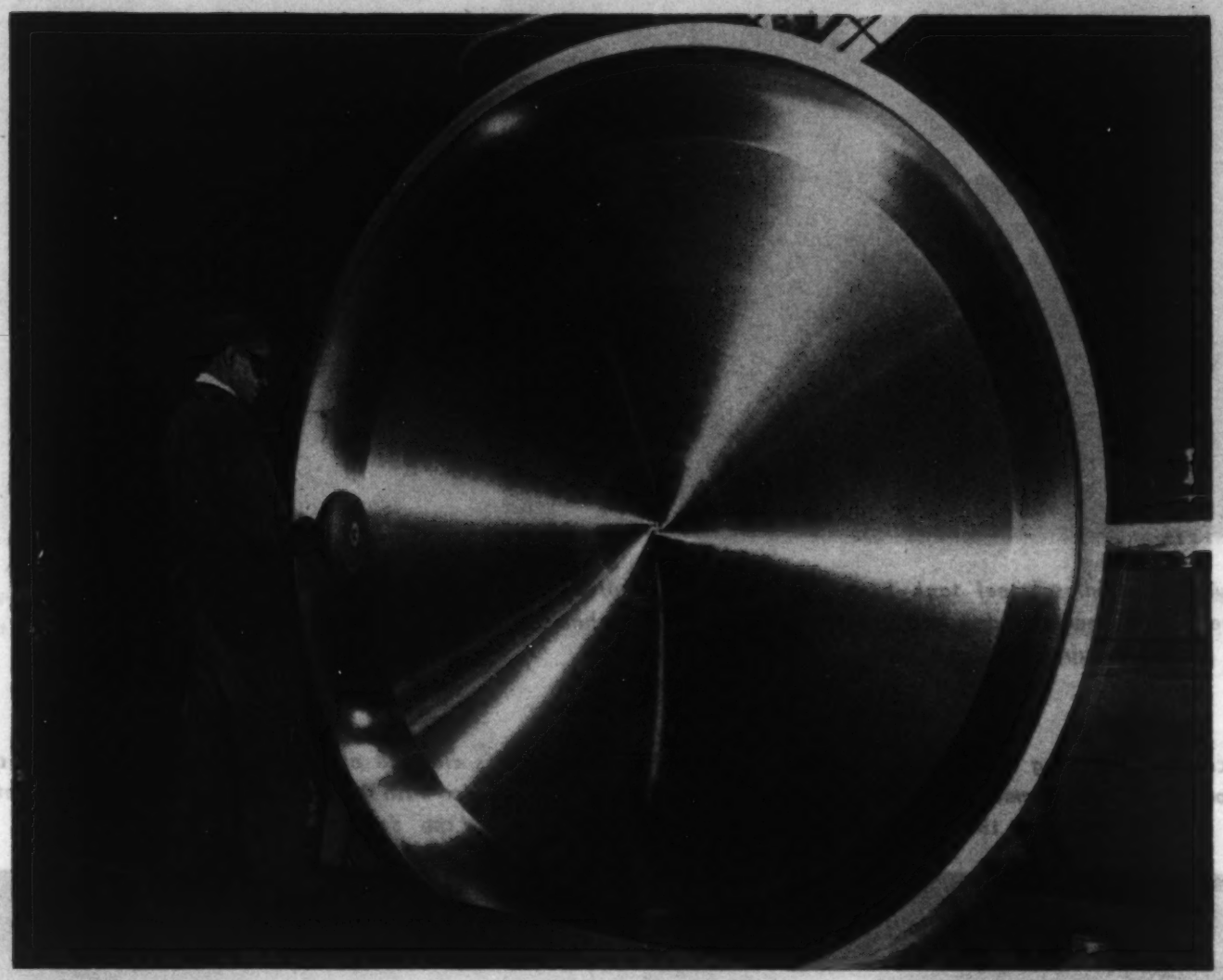
After spinning, the formed head is polished to a high finish. Care is taken to polish the weld seam so as to blend it in with the adjoining surfaces. If, upon inspection, any slight imperfections are found, they are polished out.

These stainless steel heads are most often used as inner liners for large storage tanks. Users of them report savings in cleaning and maintenance, since the liberal radii possible in spun heads minimizes cleaning time.

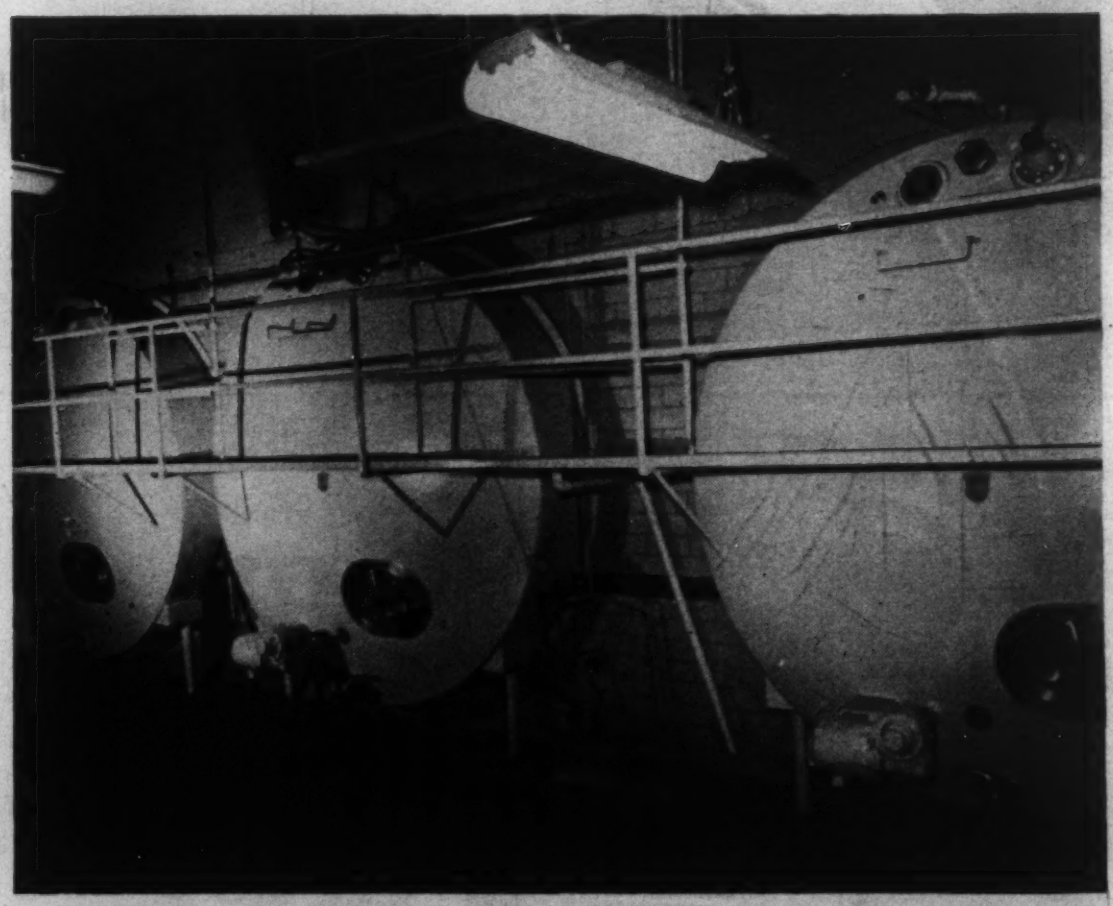
Spinning offers a versatile and practical method of forming huge 18:8 stainless steel tank heads.

3 *The early method of spinning stainless steel tank heads, shown here, required three persons. It has been replaced by a specially designed machine which spins mechanically and requires only one man.*

4 *The new method of mechanical spinning is shown here. The oversized diameter blank is clamped around its circumference. Then, as it spins rapidly, a highly polished tool steel roller, mounted in a compound, revolves in direct contact with the metal. Moving from the center out to the edge of the sheet, the tool shapes the tank head to the desired radii.*



5 *After spinning, heads are polished to a high finish. The welded seam is blended in carefully with adjoining metal. Following this, the heads are inspected and any minor imperfections are polished out.*



6 *Stationary milk tanks with outer jacket showing. These are usually just plain steel spinnings. The stainless head, with inside polished, is the end of the inner liner tank.*

In atmosphere heat treating of steel, carbon control depends on proper selection of equilibrium conditions. The curves given here will aid in this selection and control.

Control of Carbon Content During Heat Treatment of Steel in Atmosphere Furnaces

by **W. H. HOLCROFT**, Vice President and Technical Director, and
EDWARD C. BAYER, Metallurgical Engineer, Holcroft & Co.

THE WIDESPREAD USE of controlled-atmosphere furnaces is in large measure due to progressive study and understanding of the effect of atmosphere gases on the carbon content of steel during heat treatment. A direct result of this study and work has been the accumulation of valuable data on the equilibrium conditions for various atmosphere compositions and carbon contents. Because of this knowledge, gas atmospheres are used with marked success in carburizing, carbo-nitriding, clean hardening, carbon restoration, malleablizing, normalizing, bright annealing and other heat treat processes. This article outlines the basic facts of gaseous equilibrium and describes the use of equilibrium curves in the control of carbon concentration.

Furnace atmospheres are composed of a diluent or carrier gas to which is added a hydrocarbon gas in the amount required by the particular heat treat process. The most common carrier gas used today is the catalytic generator gas produced by the pyrolysis of a controlled air-gas mixture in an externally-heated retort in the presence of a suitable catalyst. A typical analysis of a catalytic generator gas using natural gas in the cracking reaction is: 0.1 to 0.3 carbon dioxide, 20.0 carbon monoxide, 0.6 methane, 40.0 hydrogen, 0.22 to 0.35% water vapor (dewpoint +10 to +20 deg. F), balance nitrogen.

For every furnace temperature, the equilibrium conditions of the furnace atmosphere will vary. These conditions are determined by the following reactions:

$$2\,CO \rightleftarrows CO_2 + C$$

$$K = \frac{(CO)^2}{(CO_2)} \qquad (1)$$

$$H_2O + CO \rightleftarrows H_2 + CO_2$$

$$K = \frac{(CO) \times (H_2O)}{(H_2) \times (CO_2)} \qquad (2)$$

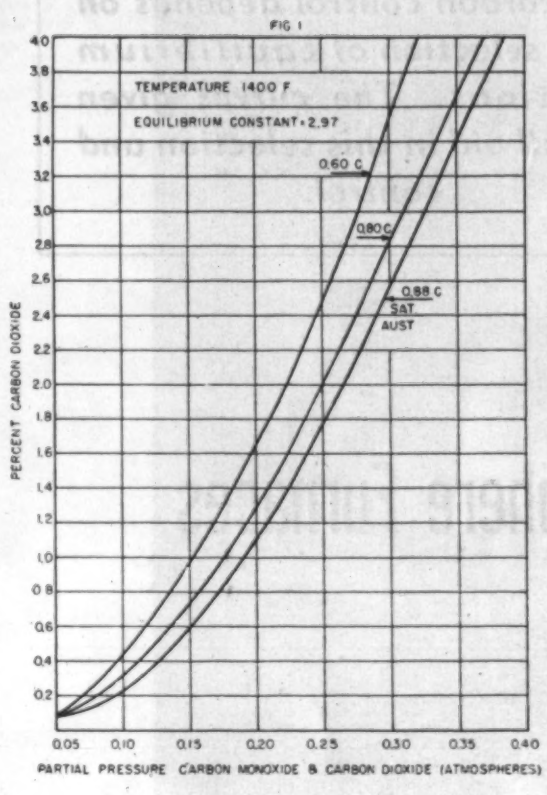
In each reaction the equilibrium constant, K, increases with increasing temperature.

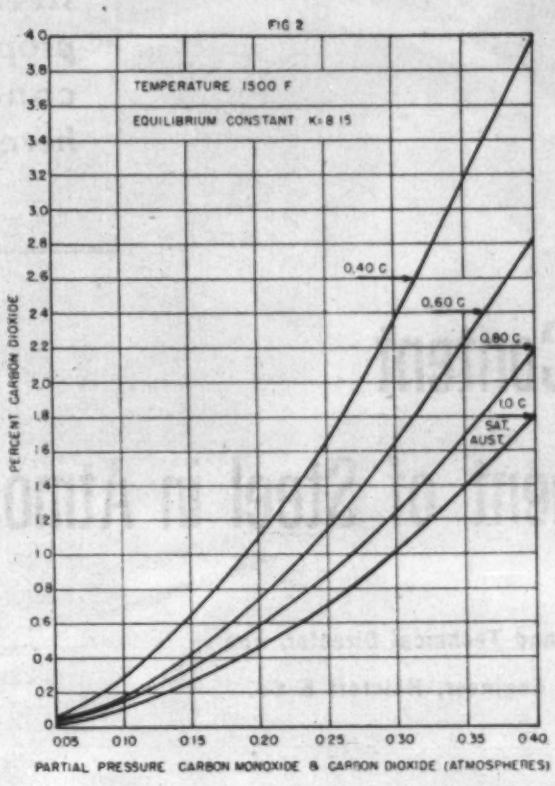
In Figs. 1 to 5, inclusive, are plotted the percent carbon dioxide versus the partial pressures of the carbon monoxide and carbon dioxide content that are in equilibrium with a given carbon content of the steel at various temperatures. The carbon dioxide content referred to is the actual percent of carbon dioxide gas in the furnace atmosphere as determined by standard gas analysis. The partial pressure, in atmospheres, is the pressure exerted by the combined carbon monoxide and carbon dioxide content as determined by the same gas analysis—*i.e.*, the sum of the percentages of these two gases.

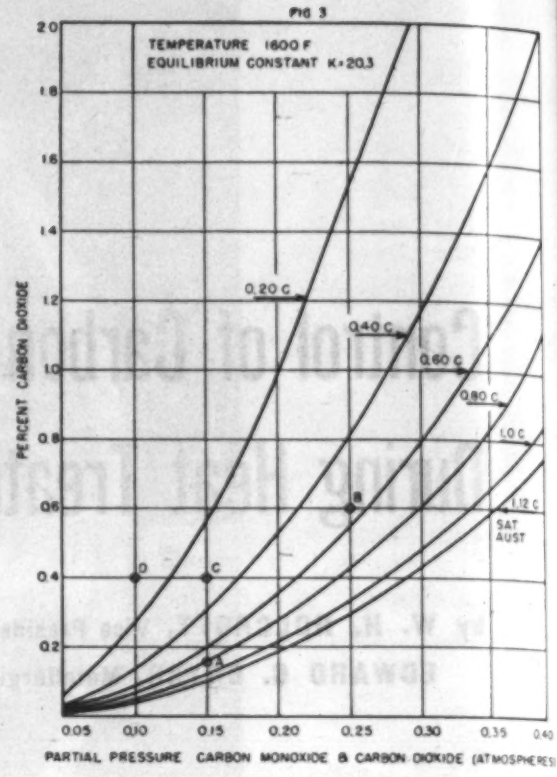
For each temperature, the carbon activity of saturated austenite is taken as unity (100%). For lower carbon concentrations, the carbon activity decreases as a straight-line function. Thus, if at 1500 F steel of 1.00% carbon (saturated austenite) has a carbon activity of 1, then 0.60% carbon steel will have a carbon activity of $\frac{0.60}{1.00} \times 1$, or 0.6; and K for equilibrium with 0.60% carbon steel at 1500 F would then be 8.15 x 0.6, or 4.89, where 8.15 is the constant, K, for saturated austenite at the same temperature.

How to Use the Curves

The accompanying curves showing the carbon monoxide-carbon dioxide equilibrium conditions are sufficiently complete for practical application to most carbon-control atmosphere conditions encountered in industry today. To determine the carburizing potential of a furnace atmosphere, it is only necessary to analyze the atmosphere for carbon monoxide and carbon dioxide content and refer to the appropriate graph. For example, assume that a carburizing furnace is operating at 1600 F and that the furnace atmosphere analyzes 0.15% carbon dioxide and







14.85% carbon monoxide. The partial pressure in this case would be 0.0015 plus 0.1485, or 0.15 atmospheres. Referring to the 1600 F curve (Fig. 3), for a partial pressure of 0.15 atmospheres and a carbon dioxide content of 0.15%, as shown at point A, we find the equilibrium content of the steel to be 0.80% carbon. This means that with the furnace conditions stated above, the surface carbon content of the steel would not be higher than 0.80% carbon.

Likewise, an atmosphere containing 0.6% carbon dioxide and 24.4% carbon monoxide at 1600 F would have a partial pressure of 0.25 atmospheres. This condition is represented by point B (Fig. 3); and the graph indicates that this atmosphere is decarburizing to a 0.60% carbon steel, carburizing to a 0.40% carbon steel, and in equilibrium with a steel of about 0.55% carbon. Point C, Fig. 3, indicates a condition where carbon dioxide content is 0.4% carbon steel, carburizing to a 0.20% carbon steel and in equilibrium with a steel of approximately 0.30% carbon. A completely decarburizing condition is represented by point D, where the furnace atmosphere analyzes 0.4% carbon dioxide and 9.6% carbon monoxide, with a resulting partial pressure of 0.10 atmospheres.

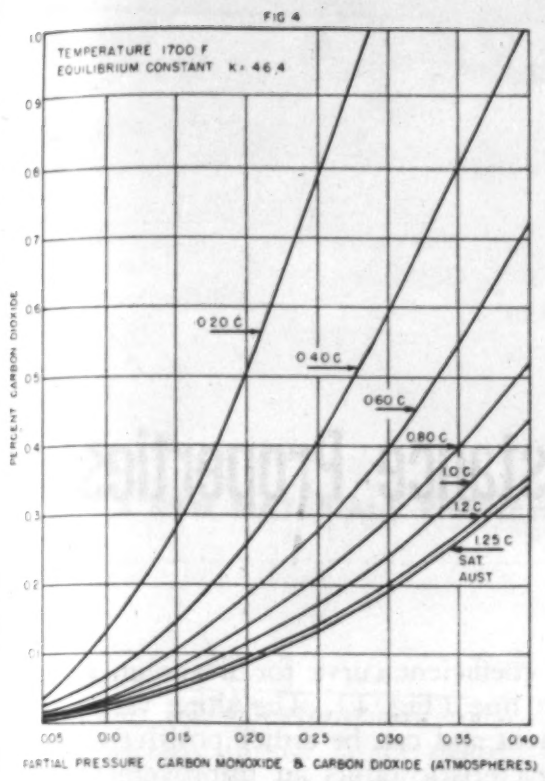
These curves clearly show that for a hypereutectoid case, the carbon dioxide content of the furnace atmosphere must be very low, whereas the lower surface carbon concentrations do not require an atmosphere devoid of carbon dioxide. For a given surface carbon concentration, the carbon dioxide content allowable in the furnace atmosphere is greater at lower temperatures.

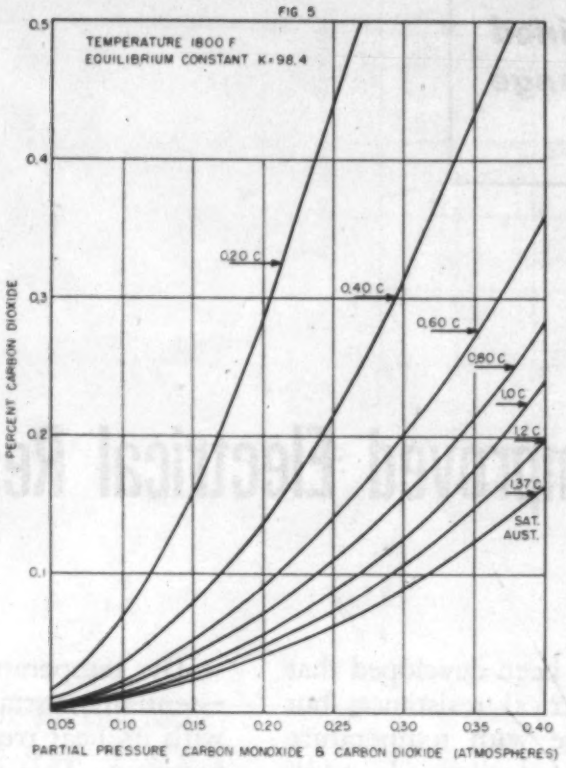
It is also true that inter-gas reactions give a higher carbon dioxide content at lower temperatures. For example, consider a sealed chamber containing a gas atmosphere and some solid carbon. If the chamber is heated to 1700 F and held at that temperature, a state of equilibrium will be established between the solid carbon and carbon dioxide and monoxide gases; for the solid carbon will react with the carbon dioxide to form carbon monoxide until equilibrium is reached, according to reaction (1). If the temperature is dropped to 1500 F and sufficient time allowed, some of the carbon monoxide will break down into carbon and carbon dioxide until a new equilibrium condition is reached.

Under practical furnace conditions, for an atmosphere containing 20% carbon monoxide, 40% hydrogen and the balance nitrogen at 1700 F, the equilibrium analysis would be 0.08 carbon dioxide, 20.0 carbon monoxide, 40 hydrogen, 0.22% water vapor (a dewpoint of plus 10 F) and balance nitrogen, in accordance with equation (2). At a reduced temperature of 1500 F with 20% carbon monoxide, the resulting equilibrium values for carbon dioxide and water vapor would be 0.48 and 0.9%, respectively.

To control the surface carbon concentration of work in a carburizing furnace, it is necessary to establish the furnace atmosphere that will be in equilibrium with the required carbon concentration. The required data are readily obtainable from the equilibrium curves.

A practical application of equilibrium data was made by Holcroft & Co. as far back as 1934, when this company built two muffle furnaces for hardening 0.60% carbon steel shafts. These shafts were finished before heat treatment and could not be decarburized. The furnace atmosphere was produced by passing a mixture of gas and air through an externally-heated alloy retort filled with broken brick, and was dehydrated by refrigeration and then introduced into the furnace muffle to envelope the shafts. The equilibrium condition of this atmosphere was





These curves (Fig. 1 to 5), showing a wide range of carbon monoxide-carbon dioxide equilibrium conditions, cover most practical applications encountered in industry today.

such that carbon would be restored to a value of 0.60% if the shafts happened to be decarburized before reaching the furnace.

It should be noted that a difference in hydrogen content will result in a variation in the dewpoint. For two atmospheres of equal carburizing strength, the one having the higher hydrogen content will have the higher dewpoint, as indicated by equation (2). Therefore, a dewpoint determination must be carefully considered in relation to the hydrogen content when evaluating the carburizing strength of an atmosphere.

In gas carburizing at about 1700 F, the hydrocarbon addition will react with the carbon dioxide in the furnace atmosphere until equilibrium is reached. At lower temperatures, the hydrocarbon reaction will be slower, and consequently a carbon dioxide content higher than equilibrium with saturated austenite may be obtained even with excess hydrocarbon present. In any case, an accurate measurement of carbon monoxide and dioxide should indicate the equilibrium surface carbon content of the steel.

To confirm this, tests were run at 1500 F with varying carbon dioxide contents and excess hydrocarbon gas. Results obtained are shown in Fig. 6.

Run No. 1 had 0.4% carbon dioxide and 18.1% carbon monoxide, and Run No. 2 had 0.7% carbon dioxide and 18.5% carbon monoxide. In both cases, the amount of hydrocarbon gas was greater than that required to produce saturated austenite. Note that Run No. 1 shows a saturated austenite surface while Run No. 2 shows a 0.60% carbon surface—both of which are predictable from the equilibrium curves.

It should be remembered that the equilibrium curves represent conditions which are more nearly approached in carburizing than in hardening operations. For hardening, an atmosphere might be in equilibrium with say a 0.60% carbon steel for a given temperature, but the amount of carbon added to a 0.40% carbon steel, or removed from a 0.80% carbon steel, would be negligible due to the time factor as well as to the small amount of carbon available before equilibrium would be reached.

Finally, it should also be remembered that equilibrium conditions are determined by the gas inside the furnace chamber and *not* by the gas *entering* the furnace. It is not necessary to introduce a zero-carbon dioxide generator gas into a furnace operating at 1500 F, as carbon dioxide will be formed in the furnace in accordance with equation (1).

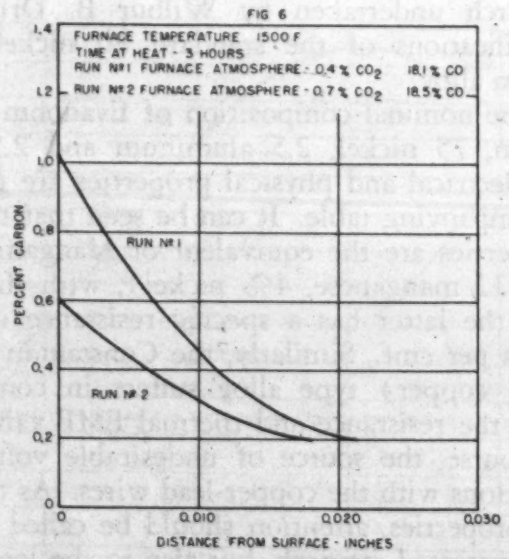


FIG 6
FURNACE TEMPERATURE 1500 F
TIME AT HEAT - 3 HOURS
RUN N°1 FURNACE ATMOSPHERE - 0.4 % CO2 18.1 % CO
RUN N°2 FURNACE ATMOSPHERE - 0.7 % CO2 18.5 % CO
RUN N°1
RUN N° 2
PERCENT CARBON
DISTANCE FROM SURFACE - INCHES

Fig. 6—The variation in carbon level with distance from the surface for different furnace atmospheres.

This new alloy should be considered wherever electrical parts require high resistance combined with a low resistance change with temperature.

New Alloy Has Improved Electrical Resistance Properties

A NEW ALLOY HAS RECENTLY been developed that has not only a higher electrical resistance, but also lower resistance change with temperature than any of the commonly accepted alloys. In addition, this temperature effect can be regulated and controlled within a narrower range than is common in other alloys by a rather simple, short-time heat treatment performed by the producer. Thus, the alloy wire and ribbon as supplied is suitable for direct processing into the product.

The logical application of this alloy wire is in wire-wound resistors, especially of the precision variety, where lack of sensitivity of resistance to temperature effects is so vitally important, whether the resistor is used in the laboratory instrument or in an electronic control for airplane flight. In the latter case, the extremes of temperature encountered are all too well known. On the other hand, the resistor manufacturer, conscious of the price he pays for his ohms, will welcome this alloy in preference to the normal copper-base alloys. Furthermore, he will find the increased strength over these same alloys will increase his manufacturing efficiency due to the enhanced ease of handling and potentially faster winding speeds.

The new alloy, called Evanohm, is the outcome of research undertaken by Wilbur B. Driver Co. on modifications of the standard 80 nickel—20 chromium alloy.

The nominal composition of Evanohm is 20 chromium, 75 nickel, 2.5 aluminum and 2.5% copper. Its electrical and physical properties are given in the accompanying table. It can be seen that the electrical properties are the equivalent of Manganin (84 copper, 12 manganese, 4% nickel), with the exception that the latter has a specific resistance of only 290 ohms per cmf. Similarly, the Constantan (45 nickel, 55% copper) type alloy suffers in comparison on both the resistance and thermal EMF value which is, of course, the source of undesirable voltages at the junctions with the copper-lead wires. As to the physical properties, attention should be called not only to the increased strength, but also to the lower value of thermal expansion which indicates less distortion in, and movement of the wire winding.

The temperature coefficient curve for Evanohm is essentially a straight line (Fig. 1). The slope varies with its heat treatment and can be either positive or negative. This characteristic offers an improvement over the copper-base alloys where the curve is usually and necessarily peaked or "humped" at about room temperature so as to obtain a low value of T.C. (temperature coefficient). On careful measurement, there appears to be a slight concavity downward to the curve, but this is negligible as it amounts to perhaps 5% of the value of the T.C. For extreme precision work, aging of the resistors is recommended to counteract a slight time instability and a hysteresis of the T.C. curve, of which a value of 0.001% has been observed.

An indication of the effect and conditions of heat treatment is shown in Fig. 2. The heat treatment involves heating the alloy up to a given temperature, which is considerably below the annealing temperature, and holding it there for a given time, after which it is cooled in air. It will be noted that there is a considerable increase in resistance at room temperature from the annealed to the heat treated value after the material has been exposed to the higher temperature of 600 C (1112 F) or more. The negative value of change of resistance above 600 C is a characteristic of this type of alloy.

A typical example of the progress of the heat treatment is shown in Fig. 3, where the changes occurring in the resistance and T.C. are plotted against the time at a selected temperature. Here again the large change in these properties induced by the heat treatment are clearly indicated, and it should be noted that while they change rapidly initially, they very gradually recover to their original values. It is for this latter reason that it has always been recommended that the wattage dissipation of the unit be insufficient to cause temperatures in excess of 300 C (600 F). However, in special applications, advantage has been taken of higher operating temperatures, and it would appear that the life stability of the electrical properties still approaches infinity even at temperatures in the neighborhood of 550 C (1000 F).

Because of its higher strength, this new alloy is naturally stiffer, requiring higher winding tension or

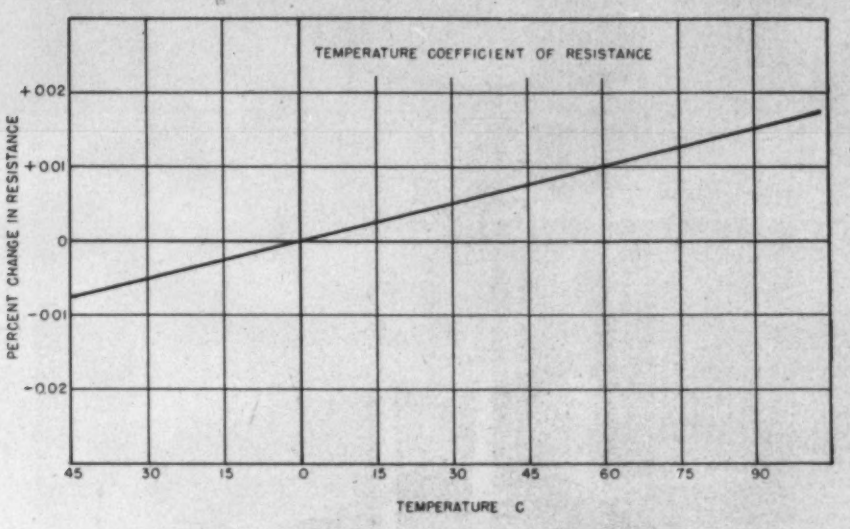


Fig. 1—Temperature coefficient curve for Evanohm showing percent change of electrical resistance with temperature.

more severe deformation to shape it to flat forms, especially in the larger gages. This same property enhances the use of self-supporting windings. Also, the high nickel-chromium alloys have always been noted for their poor soft-solderability, especially when one is confined to rosin fluxes, and Evanohm is no exception. However, no difficulty whatever is experienced with the finer sizes and it is not insurmountable in the heavier sizes. For the ribbons and wire above 0.020 in., spot-welding or brazing are readily adaptable, though with proper cleaning of the ends, even here satisfactory joints can be made with lead-tin solders.

Their possible objections, based on preconceived ideas on aluminum-bearing nickel-chromium alloys as to the aluminum content, were realized in the development of this alloy. This led to the introduction of copper into the composition of Evanohm, primarily to counteract the grain-enlarging proclivities of aluminum additions. It is also believed to enhance the solderability of the alloy.

Properties of Evanohm

Electrical Properties	
Specific Resistance	800 ohms/cmf.
Temperature Coefficient of Resistance from –50 C to +100 C	+0.00002 ohms/ohm/C
Thermal EMF vs. Copper	2.5 mv/C max.
Non-Magnetic	—
Physical Properties	
Specific Gravity	8.1 gm./cc.
Specific Heat	0.447 Watt-sec./gm./C 0.107 gm. cal.
Thermal Conductivity	0.152 Watts/cm/C
Coefficient of Thermal Expansion	0.000014/C
Tensile Strength at 30% Elongation	90,000 psi.
Tensile Strength at 1% Elongation	225,000 psi.
Tensile Strength Increase with Heat Treatment	20%

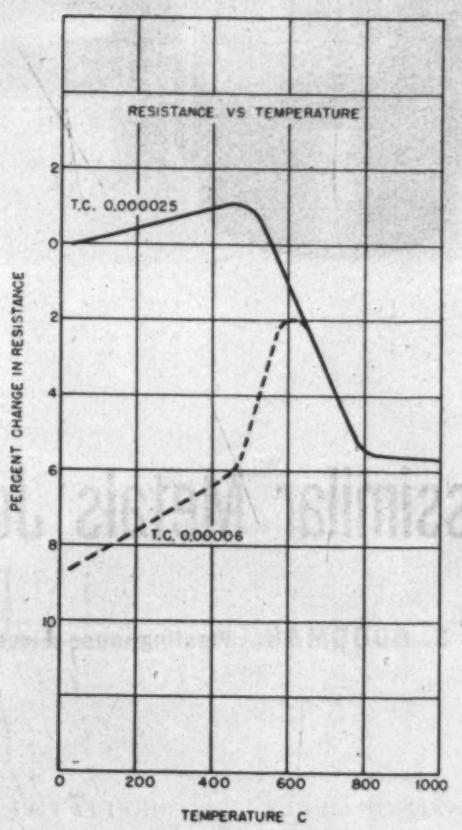


Fig. 2—Effect and conditions of heat treatment. Solid line represents heat treated condition; broken line represents annealed condition.

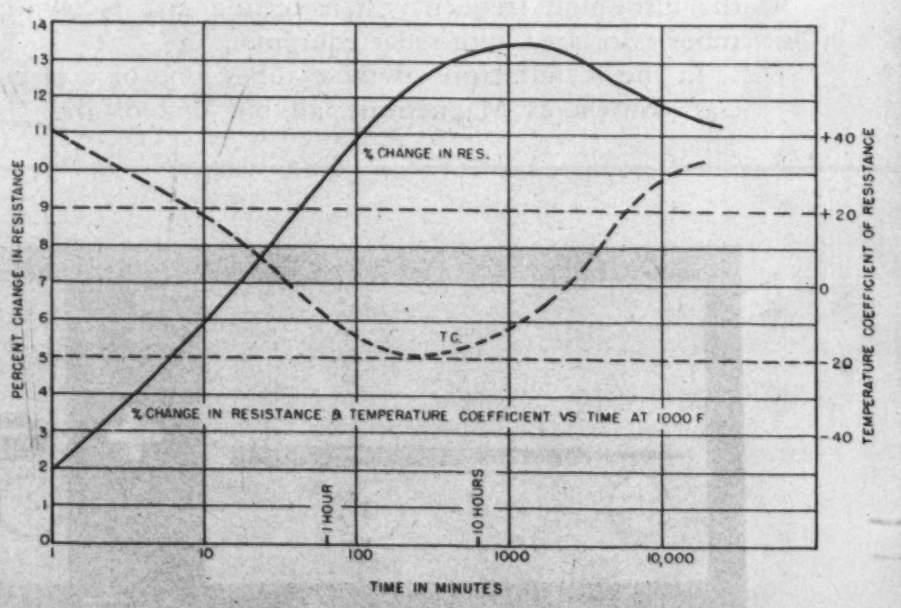


Fig. 3 —An example of changes occurring in resistance and temperature coefficient at various times at a given temperature.

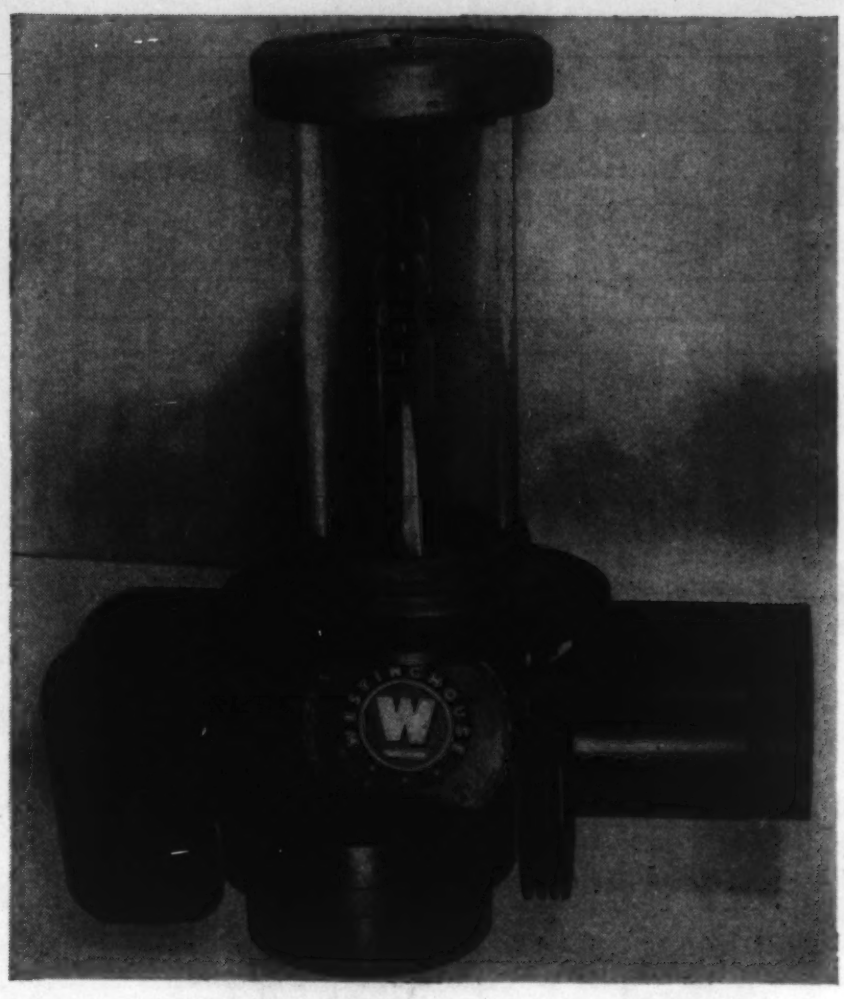


Fig. 1—This ultra, high-frequency transmitting and receiving tube, used with radar equipment, has 18 brazed joints, many of which involve dissimilar metals.

Dissimilar Metals Joined by Step Brazing Methods

by I. S. GOODMAN, Westinghouse Electric Corp.

BRAZING OFFERS AN EFFECTIVE METHOD for joining dissimilar metals, especially where a number of separate joining operations on a complex assembly are involved. A typical case is the fabrication of electronic tubes, and particularly the ultra-high frequency transmitting and receiving tubes associated with radar equipment.

In the manufacture of these tubes, one of a large class known as Magnetrons, all but one of the 18 metal-to-metal joints are brazed, and 15 of them, totaling over 50 in., must be vacuum-tight.

The metallic elements in this tube are composed of molybdenum, tungsten, Monel, stainless steel, Kovar, OFHC copper, and selenium copper. Many of these elements are subsequently enclosed with glass. Since the glass is generally applied after the braze is made and the tube, when completed, is treated at over 750 F, this temperature sets a lower limit on the

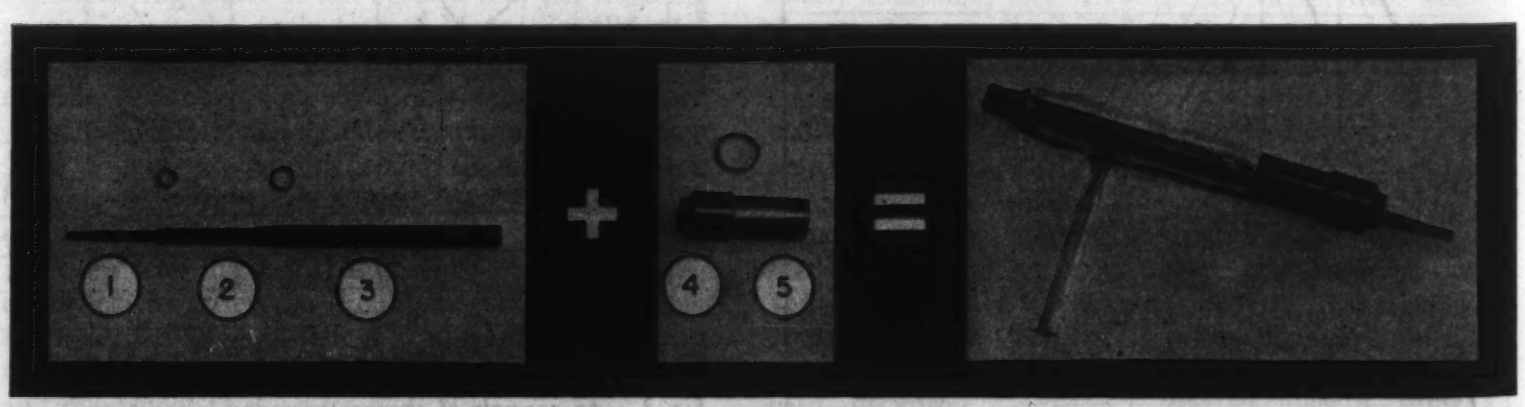


Fig. 2—Brazing steps involved in the assembly of the cathode lead.

The assembly of electronic radar tubes presents complex joining problems which are solved by a special brazing technique.

brazing alloy melting points. The upper limit is set by the parts themselves.

Since zinc, cadmium, lead, and similar metals have sufficiently high vapor pressures at 750 F to deposit themselves in undesirable locations and to degrade the vacuum, such metals cannot be part of the brazing alloys. This, therefore, limits the metals that can be used for brazing to copper, silver, nickel, gold, platinum, tin, indium, and their alloys.

A further limitation is that many of the suitable brazing metals just mentioned form eutectic systems. This means, for example, that two copper parts joined by a 50 silver, 50% copper brazing alloy cannot subsequently be brazed to another part with another copper-silver alloy within the eutectic range. For this would result in remelting the eutectic portion of the first braze with a possible shift of the parts. Nor can any other alloy of any composition of higher melting point be used for the same reason.

Other restrictions arise from the metals themselves. Tungsten is poorly wet by silver alloys. The use of silver alloys on Kovar (widely used in glass tubes because its coefficient of expansion matches glass) sometimes leads to stress-corrosion cracking similar to that experienced on steel. Finally, tolerances on many of the parts are ±0.003 in. and occasionally ±0.001 in., and concentricity tolerances on brazed parts are frequently ±0.005 in. or better.

Step Brazing Procedure

All the brazing on these tubes is performed in a hydrogen atmosphere in order to eliminate the use of fluxes (and more particularly their removal) and to keep the parts clean to avoid subsequent cleaning operations. The brazing can be done in a conventional pusher-type or continuous belt furnace or in a hydrogen brazing bottle. In the hydrogen brazing bottle the hydrogen flows through the closed top and out of the open bottom. The heat for brazing is obtained by radiation from a tungsten coil heated to 3630 F or higher.

There are eight separate brazing operations required on these tubes prior to the final assembly brazing. In order that each joint once completed is not melted by subsequent brazing operations, the technique of step brazing is used. To explain this technique, the step-by-step brazing procedure will be described in some detail. In the discussion that follows the numbers in parenthesis refer to the numbered parts in the accompanying illustrations.

Figure 2 shows the operations involved in the formation of the cathode lead. Parts consisting of tungsten (1), Monel (2), and Kovar (3), are furnace brazed with copper which has a flow point of 1980 F. The outer portion of copper (4) and Kovar (5) is furnace brazed with an alloy of 42 gold, 55 copper and 3% silver whose flow point is 1760 F. The use of this gold alloy is necessary since the copper-silver alloys may cause cracking. Copper (or higher melting point alloys) cannot be used since one of the parts is copper. These sub-assemblies are then glassed as shown to form the cathode.

The output lead, Figure 3, consists of a Kovar (6) and copper (7) subassembly brazed with the gold alloy mentioned in the previous paragraph, and a subassembly of Kovar (9) and copper and copper strap (8) brazed with an alloy of 85 copper, 7 silver and 8% tin, having a flow point of 1805 F. This alloy is good for higher temperature application

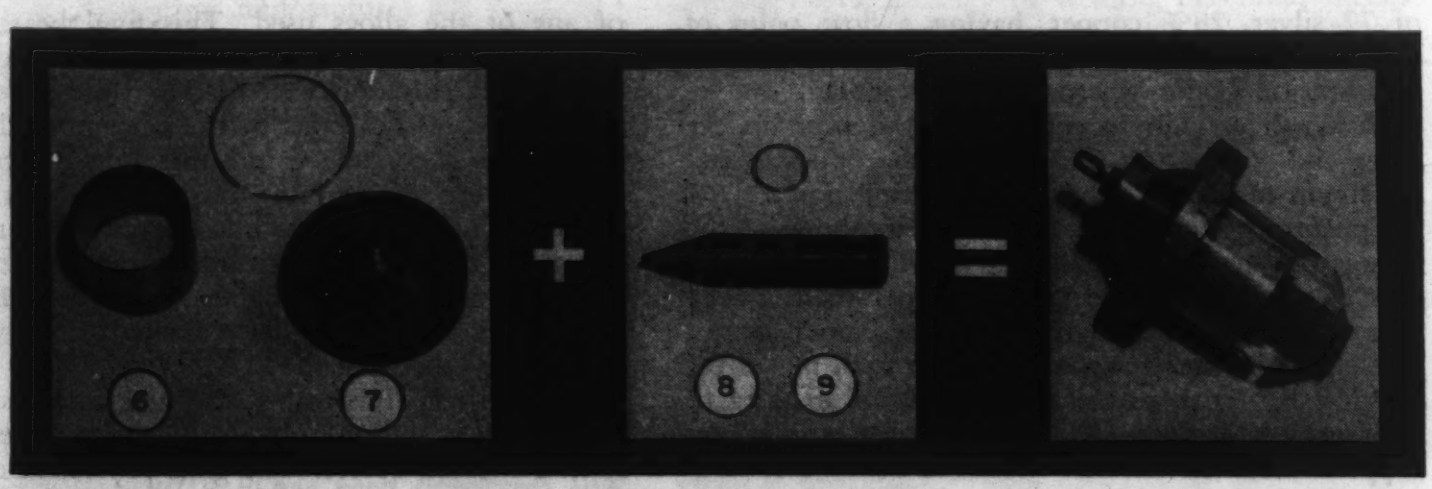


Fig. 3—Assembly steps involved in the formation of the output lead.

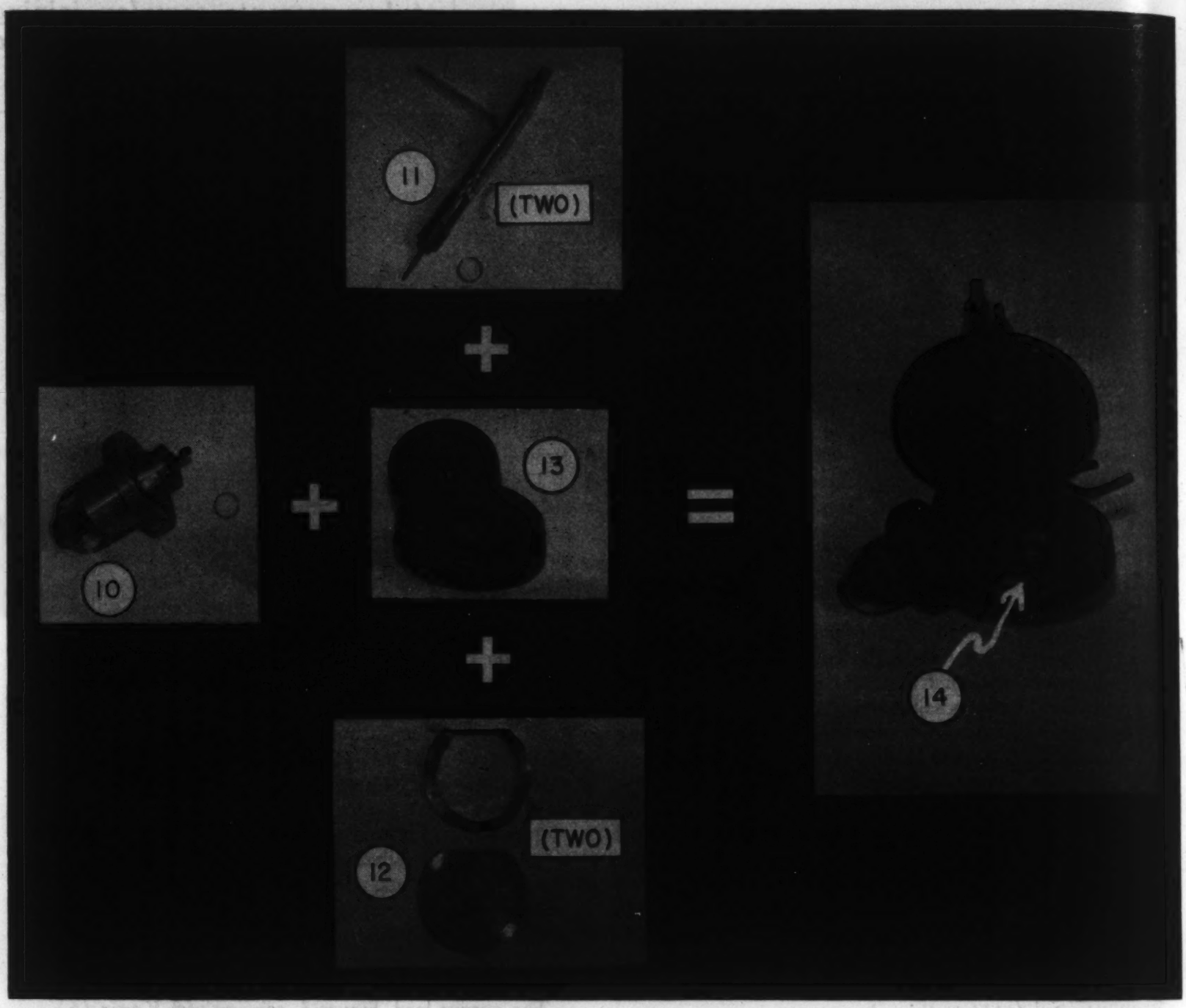


Fig. 4—Assembly of the tube body prior to final assembly of the tube.

(where copper-silver is too low) but is not as reliable for the outer vacuum joint as the gold alloy. These are then glassed to form the output lead. After glassing, the copper strap is flattened and brazed to the threaded copper part with silver-copper eutectic of 72 silver, 28% copper, having a flow point of 1435 F. This strap braze is performed in the hydrogen brazing bottle where the tungsten coil can be made small enough to concentrate the heat on the braze and still permit the glass on the opposite end to remain substantially below its melting point.

Concurrent with these operations, the body of the tube is prepared. As shown (13) in Figure 4, it consists of a hobbed veined OFHC copper shell, a selenium copper tuning cavity, and several small straps. These are all furnace brazed together with fine silver at 1760 F. To these are added a Monel diaphragm with welded Monel stud (14) by brazing with silver-copper eutectic.

In the final assembly two threaded cathodes (11), the threaded output (10), and a top and bottom copper cover (12) are brazed to the body of the tube. The brazing alloy in this final braze is a phosphorus-copper alloy composed of 93 copper and 7% phosphorus. It has a melting point of 1295 F, the lowest of any of the alloys used. This final braze is performed between the carbon electrodes of an electronically timed pulsation welder. The heat generated in the water cooled carbons by the passage of thousands of amperes is conducted into the copper parts of the tube between the carbons, raising these parts above 1290 F, and flowing the brazing alloy. During this operation, hydrogen flows through the interior of the tube, entering by one of the open glass tubulations on the cathode (11, Figure 4), circulating, and leaving by the other cathode.

After this final assembly, the tube is baked at 750 F, evacuated, and the glass tubulation tipped off to form a vacuum device. The glass protective envelope and radiator are then soft-soldered.

Brazing Alloys

Although step brazing methods such as just described have at present met the problem of joining dissimilar metals without affecting previously brazed joints, it can be seen that the way is open for newer and potentially cheaper alloys and techniques to match the advanced design changes in electronic equipment and other products where similar problems arise.

As germanium and indium become less expensive and more developed, metallurgically, the number of alloys available to the metal-joining engineer will increase. But at present those alloys with low vapor pressures, mentioned in the early part of this article, are the only ones available. Of these, copper is by far the most common both because it makes excellent joints between ferrous components and because of its low cost.

The most commonly used system is that of silver-copper. These alloys are free-flowing and fillet nicely, particularly on nonferrous alloys. However, they must be used with caution on ferrous parts under stress because of the phenomenon of stress-corrosion cracking. Also, these alloys are a eutectic system and, accordingly, some or all of the alloy will melt at 1435 F between the limits of 9 copper, 81% silver, and 8 silver, 92% copper.

Among the alloys used for brazing by the electronics industry, those containing gold have been used with success. These alloys—those of the gold-silver, gold-copper, and gold-silver-copper systems—have the advantage of flow points between those of silver-copper alloys and copper. They also flow well and wet both ferrous and nonferrous surfaces. One weakness is the occurrence of age-hardening alloys in the range of 40 to 90% gold in the gold-copper system. Some of the alloys that have been used successfully are: 75 gold, 20 copper, 5% silver (1632 F melt, 1654 flow); 58 gold, 40 copper, 2% silver (1670 F melt, 1715 flow); 42 gold, 55 copper, 3% silver (1720 F melt, 1760 F flow); and 30 gold, 70% copper (1796 F melt, 1850 F flow).

Since copper does not alloy with molybdenum and tungsten, it is found advantageous to add nickel to brazing alloys for use on such parts. Since copper and nickel form a simple series with complete miscibility in both the liquid and solid states, 10 to 30% nickel-copper alloys have been used with excellent results. Where higher operating temperatures are required, pure nickel (2650 F) has been used. Such joints will not have high tensile strengths, however, due to the formation of brittle nickel-refractory eutectics. Where both high temperature and high tensile are required, platinum (3223 F) has replaced nickel.

Where low melting points are permissible and the parts are copper, alloys containing copper-phosphorus eutectics may be used. The most common are 7 phosphorus, 93% copper (1305 F melt, 1382 F flow) and 5 phosphorus, 80 copper, 15% silver (1186 F melt, 1300 F flow). Neither alloy is recommended on ferrous alloys due to phosphiding effects with iron.

Although a gold-indium alloy with an operating temperature about 1110 F has been developed and

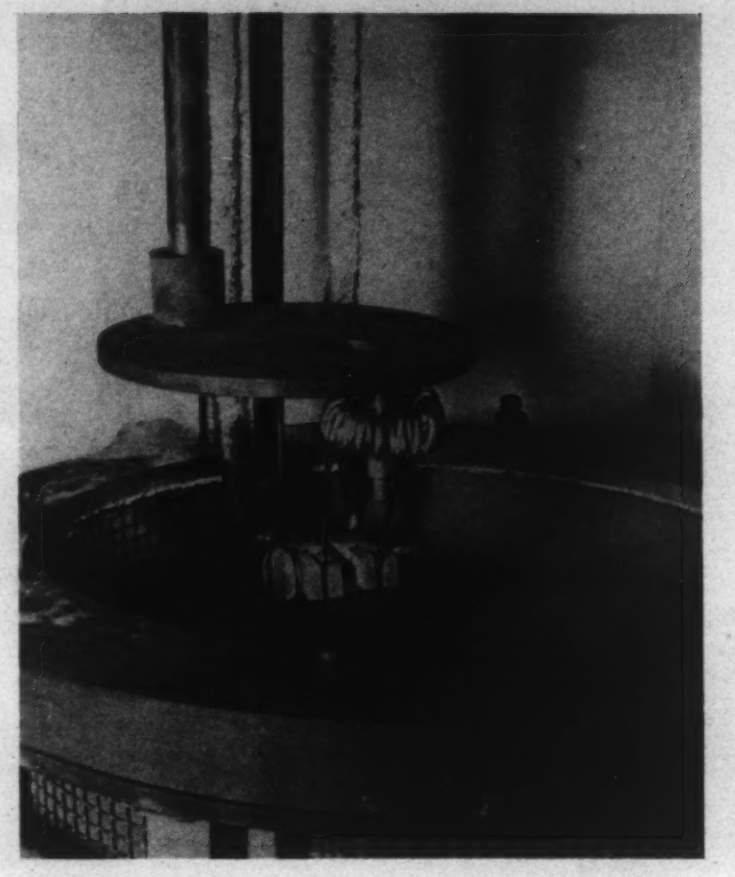


Fig. 5—A hydrogen brazing bottle is used for many of the brazing operations. Here the bottle is raised showing the tungsten coil used as the heat source.

used, there is no inexpensive, ductile brazing alloy in the field of 750 F to 1300 F that may be safely used on vacuum devices operating up to 750 F. Yet such an alloy would enjoy considerable demand. Electronic design engineers would frequently like to braze after glassing. Since the softening point of glass is about 1110 F, this sets an upper limit upon the brazing alloy whose lower limit (750 F) is set by the operating temperature of the device.

Thus far little has been said about welding other than its use in joining the Monel stud to Monel diaphragm. Welding is a potential out to the complexities of step brazing since welds can be made on semi-finished assemblies without temperature effects on previous joints. However, too little is known concerning the technology of welding dissimilar metals to obtain dependable joints of large diameter which will be consistently vacuum tight. This is particularly true for combinations of ferrous and nonferrous metals such as copper to steel or Monel to aluminum. Even with similar metals, a vacuum tight weld of 1½ in. in dia. in mild steel requires over 300 kva. single-phase welding capacity and a 2-in. dia. weld over 500 kva. Nonetheless, experiments are under way in resistance welding, arc welding, and induction welding to accomplish heretofore "impossible" welds, and joining dissimilar materials is still a challenge to both the designer and metallurgist to cooperate to the end of producing better and more efficient products.

Cotton, carded and laid up in batts, is cut into sheets of convenient size. (All photos courtesy General Electric Co.)

Cotton Fibers as a Gear Material

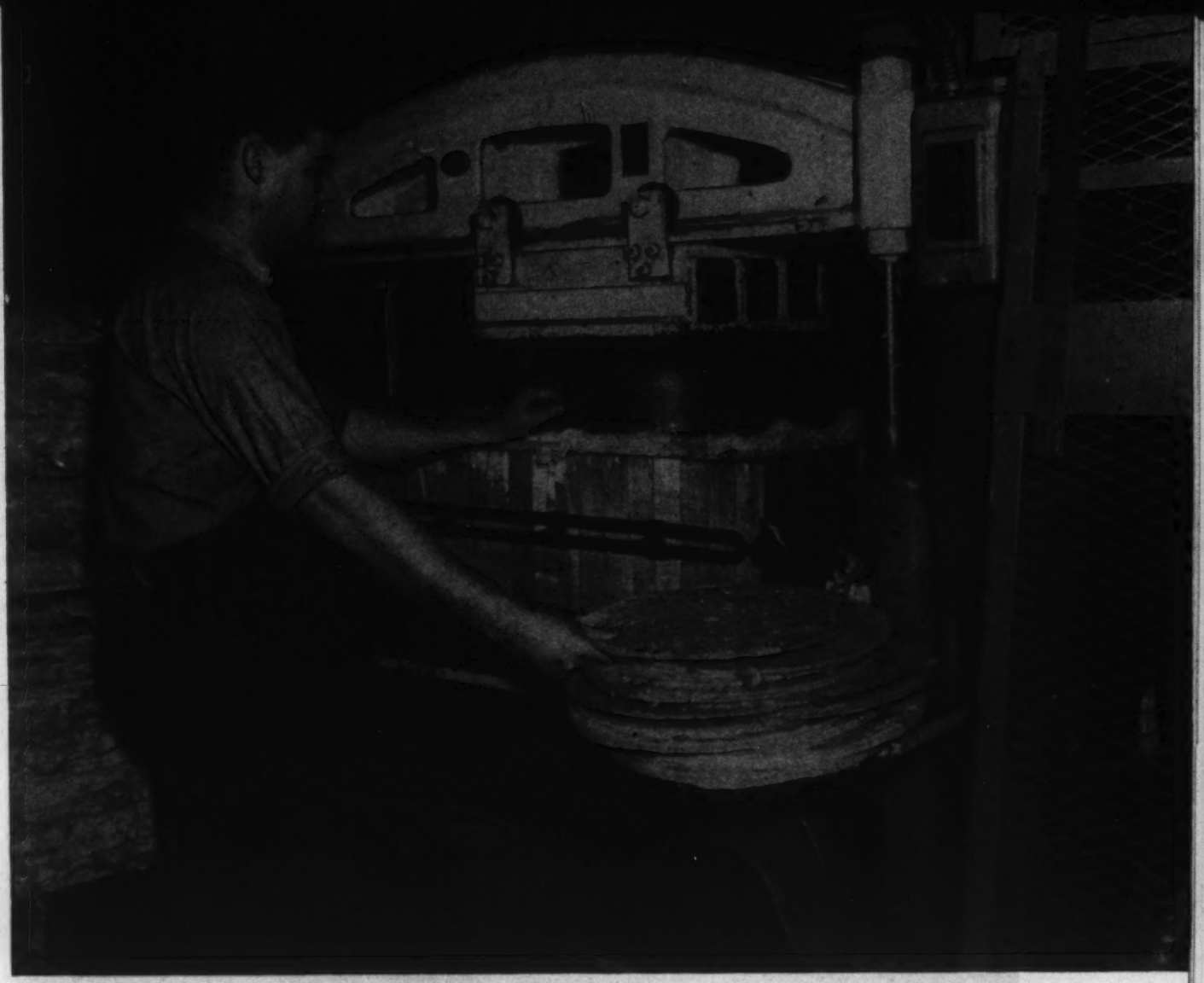
by KENNETH ROSE, Engineering Editor, Materials & Methods

THE USE OF VARIOUS FIBROUS MATERIALS as reinforcement in plastics, particularly in the phenolic resins, is a well-known means of obtaining improved impact resistance, and these reinforced phenolics are widely used for the fabrication of nonmetallic gears. Because of ready availability and ease of handling, woven cotton fibers are the most used of these reinforcing fillers. Cotton duck and lighter weaves are impregnated with the resin and laid up in piles for curing under pressure into the sheet material from which these nonmetallic gears are cut.

Cotton fibers form the basis for gears in another condition also. The unwoven material, compressed but without addition of a binder, is widely used for heavy-duty purposes in which silent running is desirable. It possesses high strength, resilience far greater than that of steel, and good toughness. When used as the basic material for gears, the compressed sheets are machined, as would be the case with metal gears. Steel shrouds and steel studs are used in connection with the cotton fiber body of the gear to provide additional rigidity.

To produce the cotton fiber gears, bales of cotton are run through a bale breaker, and the loose fibers are then carded in another machine to lay them straight and flat in batts. The cotton batts are next given a light dressing of mineral oil to reduce absorption of moisture, and to aid in the subsequent machining. A power saw cuts the batts to a convenient size for handling. The batts are then stacked between steel press plates and compressed under heat and pressure (using a hydraulic press) to compact the batt and develop desired mechanical properties in the fiber mass.

Plain, unwoven cotton is used without a binder to form gears intended for heavy-duty purposes where quiet operation is desirable.



The compressed batts are cut into disks of sufficient diameter to serve as a rough gear blank.

The batts are next cut into disks of the proper size for the gears desired. The disks are piled up until the requisite quantity for producing the face width specified has been assembled. This amount is determined by weight.

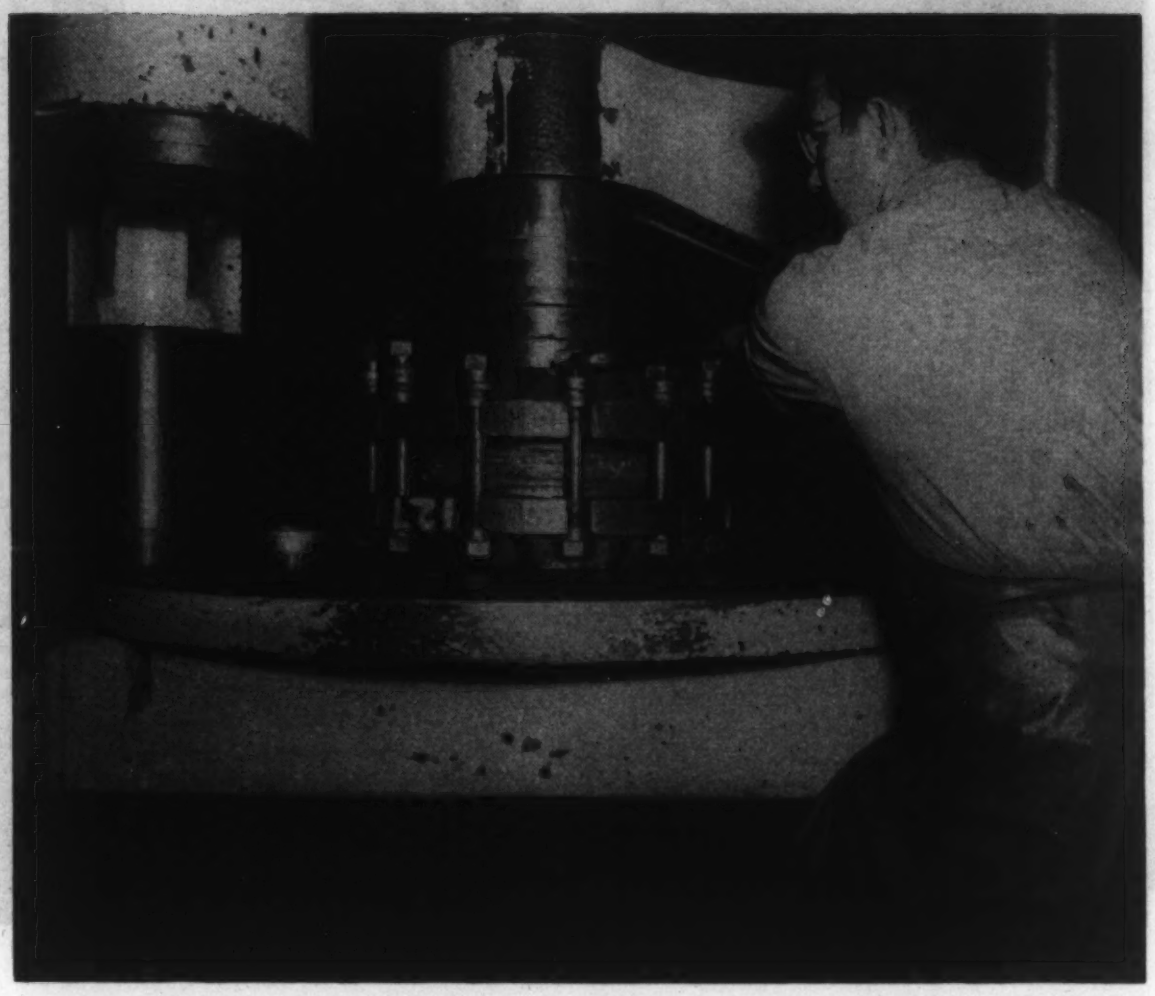
Steel cheek plates, called shrouds, are placed at the top and bottom of the stack, and the whole assembly is placed in an hydraulic press in which a clamping fixture encloses it top and bottom. The press compacts the mass until a pressure of 7 to 8 tons per sq. in. is reached. Long bolts are then swung into slots in the top and bottom sections of the fixture to join them, and the nuts are drawn up to maintain the press pressure.

The compact is removed from the press in the fixture, and taken to a drillpress where, with the pressure still maintained by the fixture bolts, holes are drilled through the cotton fiber and the steel shrouds, using the fixture as a guide. The holes are then tapped, and threaded studs are inserted to make the pressure permanent. This completes the building of the gear blank, and the fixture is removed.

The blanks are turned and bored in the usual manner, and the keyseat is cut. Boring is usually done in a lathe, with the blank roughly trued in the chuck, and a small drill run through first. The piece is then drilled to reaming size, and the reamer finishes the operation. A liberal supply of oil is used during the reaming. The blank is then pressed onto an arbor and turned in a lathe, using tools ground about as for mild steel. After the tool has moved past the first steel shroud, the speed of the lathe is increased to its maximum for the cut over the surface of the cotton. The speed is again changed as the tool reaches the second shroud. After turning the blank to the finished outside diameter, both steel shrouds are faced.

A single-cutter machine is preferable to a broach for cutting the keyway. A broach can be used, however, if the drag is not too great.

The gear teeth can be cut on a hobber, milling machine, or shaper. Sharp cutters are an essential factor in obtaining good results. The difference between the hardness of the steel shroud and the cotton material makes it advisable to adjust the cutter when leaving one material and entering another when possible, even with a sharp cutter. The cutter should be



The cotton disks are compressed between steel shrouds in a steel fixture. Bolts are drawn tight to maintain pressure after removal from the press.

sunk 0.003 to 0.005 in. deeper in the cotton than when cutting steel, to allow for the greater resilience of the fibrous material. Speed of cutting may be increased through the cotton, if the method of cutting permits.

Care should be taken to prevent steel chips being driven over or into the cotton body by the cutter. Application of a stiff wire brush to the cutter to prevent loading with steel chips will help here.

In use, the cotton gears should alternate with metallic gears in the train. The metal gears are best made of hard, abrasion-resistant steel, with a hardness up to 300 Brinell. The train should be carefully protected from abrasive substances, as these will become imbedded in the cotton gear and cause excessive wear. Lubrication should be adequate also. Careful design and cutting of the teeth to minimize the drag of teeth of one material over those of another is an important factor in obtaining long life of the gears in service. Deflection of the teeth, which is considerable in the case of the cotton gears, and is the chief factor in their quietness of operation, must be allowed for in considering tooth form. The number of teeth in contact should be at least 1.4, as calculated by

$$\frac{\text{length of effective line of action}}{\text{base circular pitch}}$$

Face width of cotton fiber gears should be wide enough so that mating metallic gear teeth will not contact the steel shrouds.

A tabulation of safe working stresses for a range of velocities is given to assist in calculating the allowable tooth load with cotton gears. Velocities here are those at the pitch line of the gear.

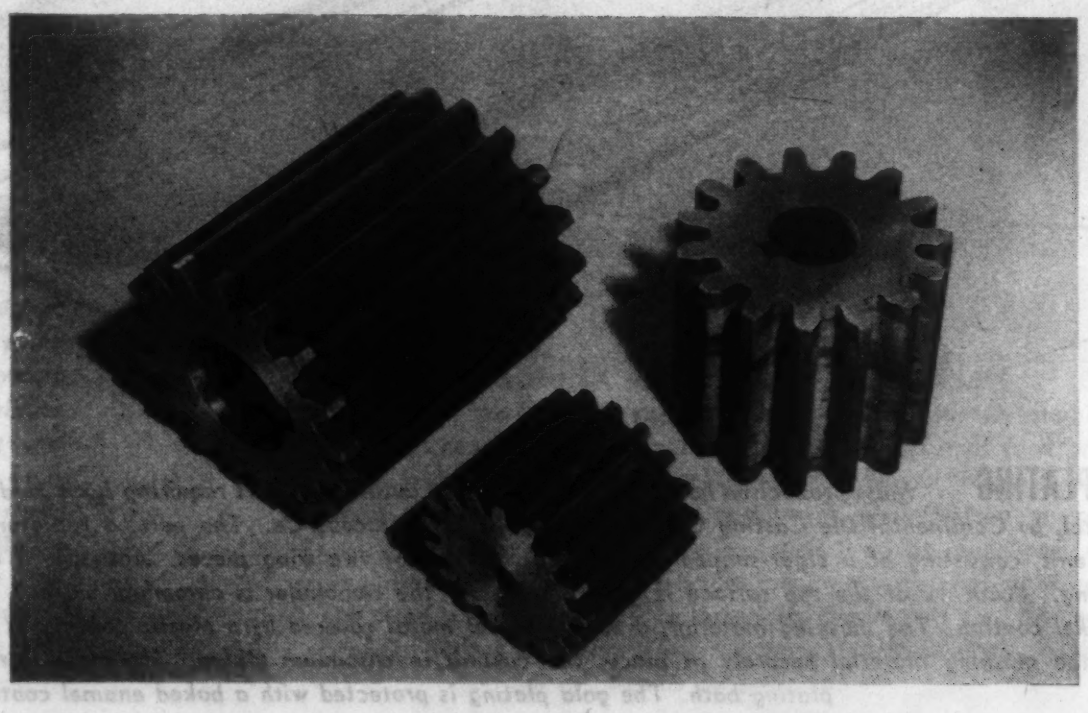
Pitch Line Velocity	Safe Working Stress	Pitch Line Velocity	Safe Working Stress
100	6000	1900	2571
150	5430	2000	2545
200	5000	2100	2521
250	4667	2200	2500
300	4400	2300	2480
350	4182	2400	2462
400	4000	2500	2444
450	3846	2600	2429
500	3714	2700	2414
600	3500	2800	2400
700	3334	2900	2387
800	3200	3000	2375
900	3091	3100	2363
1000	3000	3200	2353
1100	2932	3300	2343
1200	2857	3400	2333
1300	2800	3500	2324
1400	2750	3600	2316
1500	2706	3700	2308
1600	2667	3800	2300
1700	2632	3900	2293
1800	2600	4000	2286

Pitch line velocity is given in ft. per min., and safe working stress in lb. per sq. in.

After being permanently assembled under pressure by studs, the oil impregnated cotton gear blanks are turned, bored and cut.

The static stress recommended for compacted cotton gears is 8000 psi., the same as for a good grade of cast iron when used in gearing.

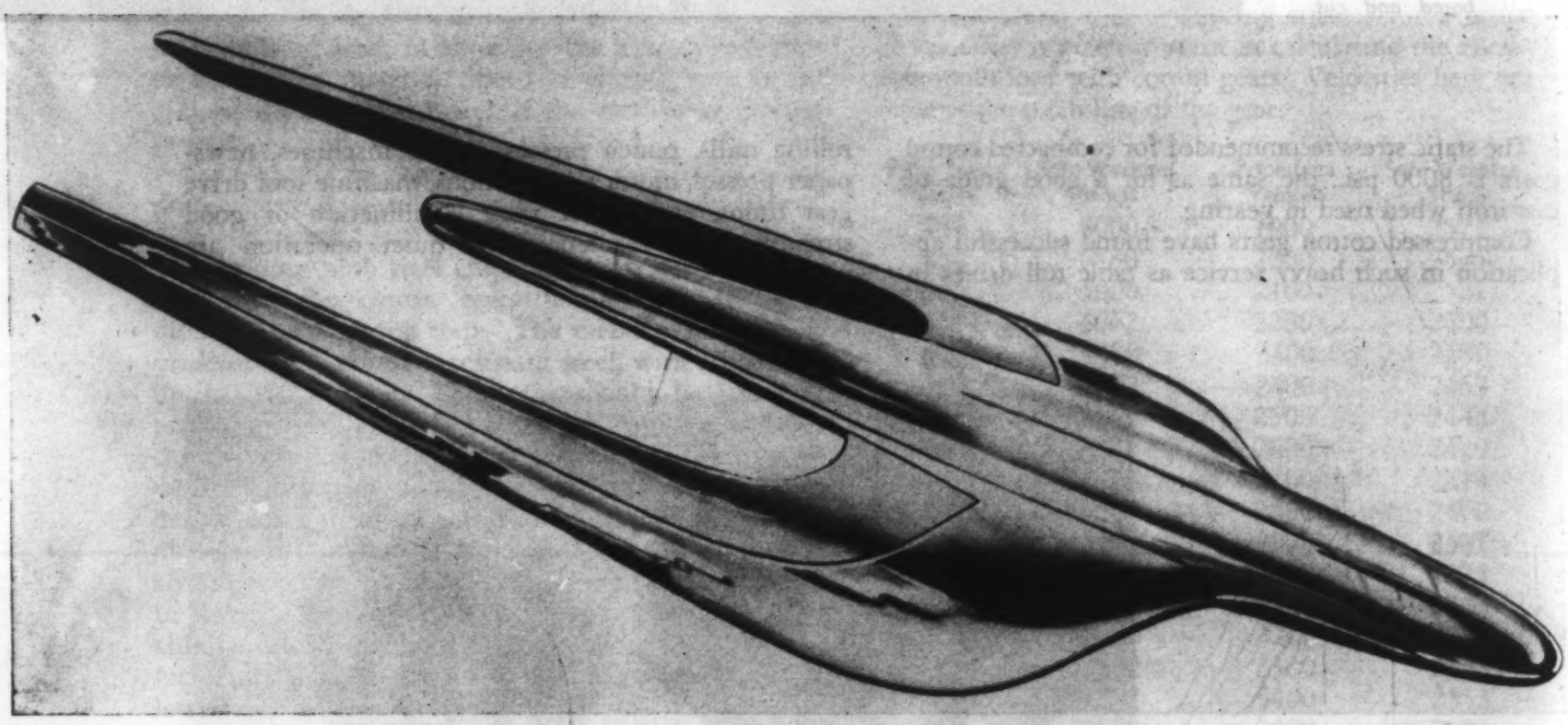
Compressed cotton gears have found successful application in such heavy service as table roll drives in rolling mills, punch presses, textile machines, newspaper presses, motor shaft pinions, machine tool drive gear trains, etc., where their combination of good strength, great resilience, and quiet operation are valued.



Shown here are completed Fabroil gears ready for service.

Materials at Work

— A special feature devoted to showing how materials are used as well as why they are used in their newer applications. Here you will find interesting, informative items and illustrations showing the methods by which progressive engineers are taking advantage of the properties of materials—both new and old.



TWO-TONE PLATING *Mass production has been achieved on an automotive part requiring both gold and chromium plating on a single piece of die cast metal, by Continental Die Casting Corp., a division of F. L. Jacobs Co. The part, a radiator ornament for a 1949 model car, looks like a 3-piece unit, consisting of a cigar-shaped centerpiece, flanked by two wing pieces. Actually, it is a single piece zinc alloy die casting, about 20-in. long. About ¼ of the top surface is gold plated and the remainder is chromium plated. The casting is first given a copper bath and then a nickel coating. The masking material, a copper-nickel metal covered by a plastic coating, is then bridged across the area to be gold plated. With the masking material securely in place, the casting is chromium plated. The mask is removed and the casting goes to a gold plating bath. The gold plating is protected with a baked enamel coating.*

FAST CUTTING OF TOUGH MATERIAL

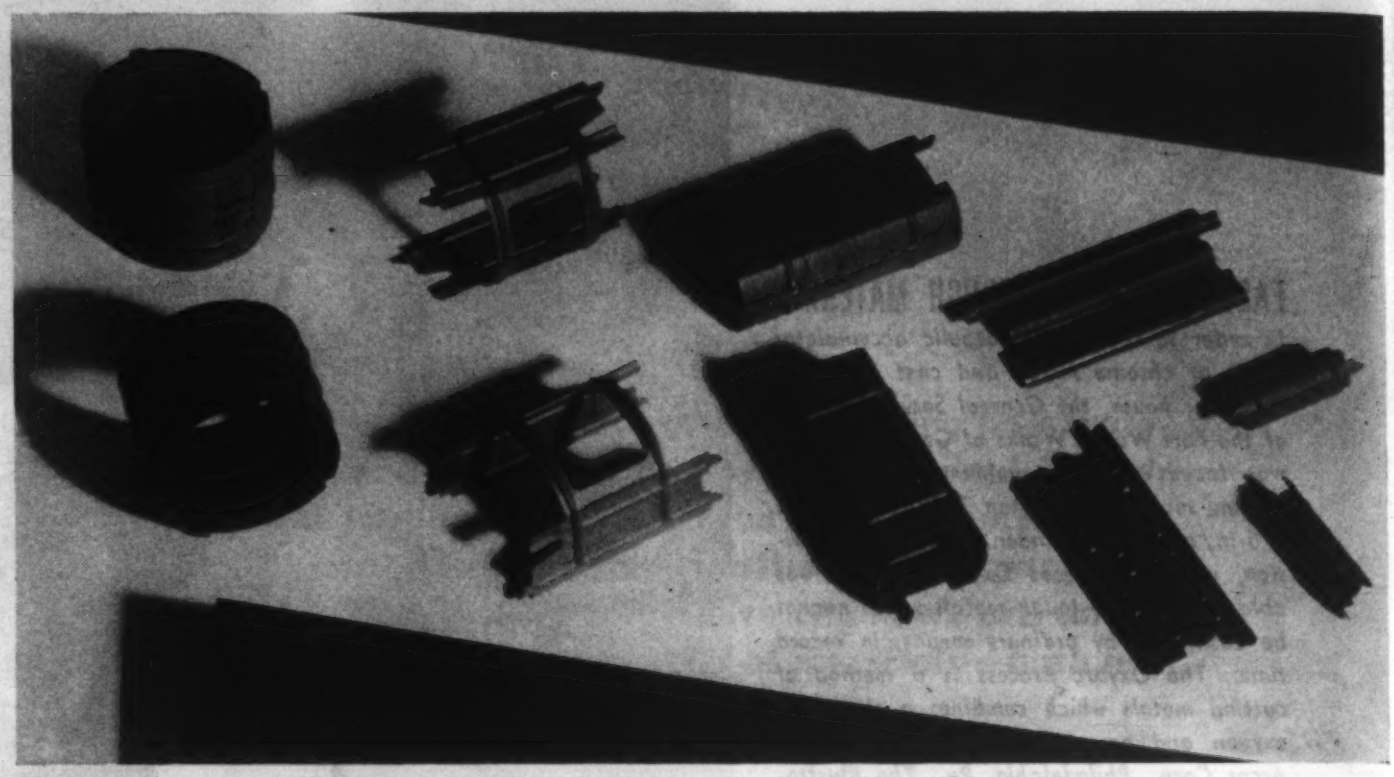
In order to remove a hydraulic accumulator made of chrome nickel and cast iron from its power house, the General Service Division of the Fort Wayne Works of General Electric was faced with the problem of cutting a chrome nickel steel piston 3½-in. thick and a 5-in. cast iron cylinder. The Service Division, using the Arcos Oxyarc Process, was able to cut these tough metals which cannot be easily cut by ordinary means, in record time. The Oxyarc Process is a method of cutting metals which combines a stream of oxygen and an electric arc, developed by Arcos Corp., Philadelphia, Pa. The illustration shows the operator, using the Oxyarc holder, in the process of cutting the cylinder, and the finished cut in the insert.

PRINTED CIRCUITS ON PLASTICS

What is believed to be the first use of a plastic base for printed electric circuits is revealed by Telex, Inc., Minneapolis, in its new hearing aids. The circuit, printed in silver, is placed on polystyrene wafers 1-11/16 in. long and 1-5/32 in. wide. The use of a plastic base, rather than ceramic base materials formerly used, provides increased lightness, flexibility, durability and imperviousness to humidity conditions. The entire bearing aid built around this circuit weighs only 5 oz., including batteries.

STAINLESS-COPPER CLAD FOOD EQUIPMENT

One of the first commercial applications of Rosslyn metal—stainless steel and copper bonded together—is in the making of food processing and candy making machinery. The copper is sandwiched between layers of stainless steel and proves advantageous for cooking applications where the stainless steel provides cleanliness and durability, while the copper provides quick even distribution of heat. The Rosslyn metal is made by American Cladmetals Co., Carnegie, Penna. Savage Brothers Co., Chicago, fabricate their cooking vessels by spinning.



ALUMINIZED STEEL IN SMALL METAL PARTS

A recently developed aluminized steel is being used extensively in vacuum tube parts by Sylvania Electric Products, Inc. Advantages of the material include heat-radiating properties 85% of the perfect black body; minimum gas evolution during tube manufacturing operations; good welding properties. In addition, the material eliminates the possible transfer of carbon during manufacture which sometimes occurs with carbonized nickel-plated steel parts. The material is made by hot rolling low carbon rimming grade steel to 0.080 in. and then cold reducing to 0.040 in. This strip is coated with an aluminum-silicon alloy, rolled to 0.005 in. and annealed in hydrogen. The finished strip is ductile and has a black finish. Development of the material was a joint venture of Sylvania and Armco Steel Corp.

STATIC CONDUCTING RUBBER

The B. F. Goodrich Co. is using a new static conducting synthetic rubber for making gasoline hose nozzles. The new material does not require metal reinforcing of any kind, either for strength or conductive properties. Field tests indicate that the rubber nozzles will outlast metal nozzles by more than twice. Many other advantages are cited for the material in this application, including imperviousness to gasoline, oil, sunlight and cold; completely flexible; no marring of car finishes; and, faster filling.

ATERIALS & METHODS MANUAL

This is another in a series of Manuals on engineering materials and their processing published as special sections in Materials & Methods. Each manual is complete in itself and is intended to serve as a reference book on the subject covered. These manuals provide the reader with useful data on characteristics of materials or fabricated parts, and on their processing and application. Preceding manuals have taken their places in the permanent reference files of thousands of readers.

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Bearing Metals

by H. R. Clauser, Associate Editor,
MATERIALS & METHODS

Wherever moving parts that require a sleeve bearing are involved, the group of materials commonly referred to as bearing metals must be considered. This manual outlines the requirements of sleeve bearing materials, and discusses properties and characteristics of the many different bearing metals. It also gives the materials engineer some helpful advice on selecting the proper bearing metal for a particular application.

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August 1948

Materials & Methods

A typical group of porous metal bearings. Types include plain, flange, thrust and spherical bearings. (Courtesy: Amplex Manufacturing Div., Chrysler Corp.)

Introduction

Practically all engineering metals and alloys have at one time or other been considered as sleeve bearing metals. And all have at least a few minor applications where their bearing characteristics are an important factor. However, a number of groups of alloys have proved especially fitted to sleeve bearing use, and it is only these that will be covered in detail in this manual.

Another major class of bearings, the anti-friction type involving roller or ball bearing assemblies, are constructed chiefly of steels and do not present the same bearing or frictional problems encountered in sleeve bearings. They will not be discussed here.

Sleeve bearing assemblies involve three principal elements: a journal or shaft which is usually the rotating member, the bearing, and a very thin film of lubricant between the shaft and bearing. If a perfect oil film could be maintained between these relatively moving surfaces, the problems normally encountered with sleeve bearings would be largely eliminated. However, a perfect, non-breakable oil film is practically impossible to achieve. Sleeve bearing designs must take this into consideration, and they attempt to do so by using alloys which will not fail under momentary metal-to-metal contact under the required service conditions.

This behavior under metal-to-metal contact is therefore a major distinguishing characteristic of bearing metals. There are, of course, other characteristics that must be considered, and they will be discussed in some detail later.

Finding a yardstick to measure and evaluate the performance of bearing metals is not an easy matter; there is no one test or group of tests that will completely evaluate bearing characteristics. Nor can the usual mechanical properties, such as tensile strength, elongation, hardness, etc. be relied upon. Most evaluations at present are still based on past experience and on actual tests of materials in service. Such service tests, although valuable for a specific case, can be misleading if results are interpreted in a general way for other applications. Therefore, even service tests must be considered only qualitatively and for one given set of conditions.

But in spite of the obvious limitations of field tests and of observation of bearing materials in service, it is the accumulation of knowledge secured in this manner that must be heavily relied upon when searching for the best alloy to use in a particular bearing application.

Requirements of Bearing Metals

In discussing and judging the performance of bearing materials, a number of pertinent characteristics or properties must be considered, and these will now be discussed in some detail before taking up the materials themselves.

Bearing Properties

To perform satisfactorily as a bearing, a metal must first have certain characteristics which concern its behavior when it bears on or moves against another metal. An essential characteristic is *wettability*, or affinity of the metal for lubricants. No metal acting as a bearing will stand up very long under direct metal-to-metal contact. For successful operation its surface must be able to absorb or have formed a strong, tough oil film that is easily repaired when broken.

Unfortunately, this wettability is a kind of intangible thing, and thus far attempts to measure it have not been too successful. One approach to it is in terms of chemical reactivity. This is based on the fact that the metal reacts chemically with ingredients in lubricants, such as the sulfides or dissolved oxygen. Such a reaction forms an adherent film on the surface to prevent metal-to-metal contact. According to this theory, an indication of the affinity of a metal for lubricants is given by its position in the electrochemical series, since position in the series indicates relative chemical activity.

Even though the metal may be very receptive to bearing lubricants, there is probably no bearing application in which this oil film does not break down for at least very brief periods of time. In practice, shafts and bearings are not perfectly smooth; projections stick through the oil film and cause metal-to-metal contact. Besides, shafts and bearings are not always perfectly rigid or fitted precisely. Also, dirt in the lubricant, or metal filings from shaft or bearing can rupture the film. Finally, a great many bearings start under load, and a short period of metal-to-metal contact must be allowed for until the oil film becomes effective.

These momentary metal-to-metal contacts can be disastrous if the metal does not have what are generally termed good bearing properties. Probably more study and testing has been devoted to these properties than to any others. And yet there is still much disagreement over what they are and their relative importance. The best we can do is list them and explain what we believe their generally accepted meaning is.

When metal-to-metal contact occurs in a localized area, the heat that is created can lead to a welding or seizure of the contacting surfaces. This welding can result in a piece of the bearing being torn out, subsequently causing scoring or galling. If the welding gets progressively worse, complete seizure of shaft and bearing can result. Or, the frictional heat can lead to melting of the bearing. The ability of a metal to prevent all these things from happening is variously referred to as frictional or antifrictional properties, anti-seizure properties, or as resistance to scoring or galling. Here these characteristics will be referred to as *anti-seizure* properties.

Closely related to anti-seizure characteristics is thermal conductivity. It is generally accepted that bearing metals must have higher than average thermal conductivity, because it contributes to good anti-seizure properties. When metal-to-metal contact occurs, materials with high thermal conductivity carry away the heat from the local hot spot, and tend to dissipate it over the bearing surface from which it is removed by the oil stream.

Another bearing characteristic usually considered necessary in bearing metals is *embeddability*. This refers to the ability of the metal to embed in itself dirt, grit, or filings which almost always are present in the oil system. In bearings lacking good embeddability, the foreign particles in the oil stream travel around in the bearing assembly or stick on the surface of the bearing and act like an abrasive, scoring either or both the shaft and bearing; or they can cause local overheating leading to welding or seizure. The mechanical properties generally considered most closely related to embeddability are yield strength and hardness. Low yield strength and low hardness are believed to be conducive to good embeddability.

A third bearing property, termed either *conformability* or *deformability*, refers to the ability of a metal to deform slightly to compensate for small misalignments or irregularities in the bearing assembly. Without this ability, high local pressures caused by deflections in the assembly while the shaft is rotating cannot be relieved and can lead to seizure. A low modulus of elasticity and low yield strength are generally believed to be desirable for good conformability. A metal with low elastic modulus is believed to be able to yield elastically to local pressures and thus relieve the pressure.

A prevalent theory is that this conformability characteristic is also important in taking care of dirt and grit in the bearing lubricant. According to this theory, which conflicts with the embeddability concept, when a foreign particle is pressed against the bearing, the bearing metal deforms elastically under the impact much like a rubber tire passing over a stone. When the particle moves on, the metal returns to its normal position. This elastic deformation is repeated until the particle is washed free of the bearing.

As was mentioned previously, a great amount of testing has been devoted to evaluating these three bearing properties. They are difficult to separate and pin down, and most tests can only give an indication of properties under a specific set of conditions. The variables are many and include speed, bearing load, kind and degree and cleanliness of lubrication, surface finish, and operating temperatures.

Strength Properties

Besides having good bearing characteristics, a metal to function satisfactorily as a bearing must be able to carry the load imposed on it for some specified time under maximum operating conditions and temperature without permanent deformation or failure. Therefore, aside from bearing properties, the life of a bearing is largely determined by the strength of the bearing metal. There are three types of strengths which are usually considered in bearing studies. These are *fatigue, compressive,* and *impact* strengths. However, here again as with bearing properties, there is some disagreement as to their meaning and relative importance.

The *load carrying capacity* of a bearing is calculated on the basis of its projected surface area, and bearings are usually rated according to this calculated unit load. This figure, however, is not necessarily equivalent to the strength required in the bearing material to withstand the imposed bearing load. The calculated unit load is usually quite low compared to the unit stresses actually encountered by the bearing metal in service. For in many applications when a bearing is in operation the total load is concentrated almost entirely along a line of contact between the shaft and bearing metal; therefore, the actual unit pressure is much greater than the unit load calculated on the basis of the projected area.

Some Important Definitions

Anti-seizure properties—ability of bearing to resist welding to shaft, when momentary metal-to-metal contact occurs. Also termed resistance to scoring or galling, or anti-frictional properties.

Embeddability—ability of bearing metal to embed in itself foreign matter.

Conformability or deformability—ability of metal to deform elastically to compensate for irregularities in bearing assembly.

Load carrying capacity—maximum load in pounds per square inch that bearing can safely carry under operating conditions. It is calculated on basis of projected surface area of bearing.

Fatigue strength—generally used to refer to bearing life or endurance of bearing under a given load and set of operating conditions.

Impact strength—ability to resist permanent deformation under shock loadings.

Compressive strength—ability to resist permanent deformation or "squeezing out" under the applied loads.

Corrosion resistance—resistance to attack by organic acids present or formed in bearing lubricants at operating temperatures.

Wettability—affinity of metal for lubricants.

Compressive strength as such is usually considered no problem, probably because in most bearing designs the compressive strength of the metal is always much higher than necessary to carry the imposed load. However, from the standpoint of undirectional loading, there is a definite upper limit to the load carrying capacity of various bearing materials.

More often, fatigue strength is used as an indication of bearing life, because in most bearing applications repeated stresses are usually involved at least to some degree. The sources of these alternating stresses are debatable, and have been the subject of wide discussion. The principal sources seem to be (1) the direct load from the shaft, which is primarily compressive, but also introduces secondary tensile stresses; (2) the stresses set up by flexure of the bearing assembly and (3) the stresses set up by imposed alternating loads.

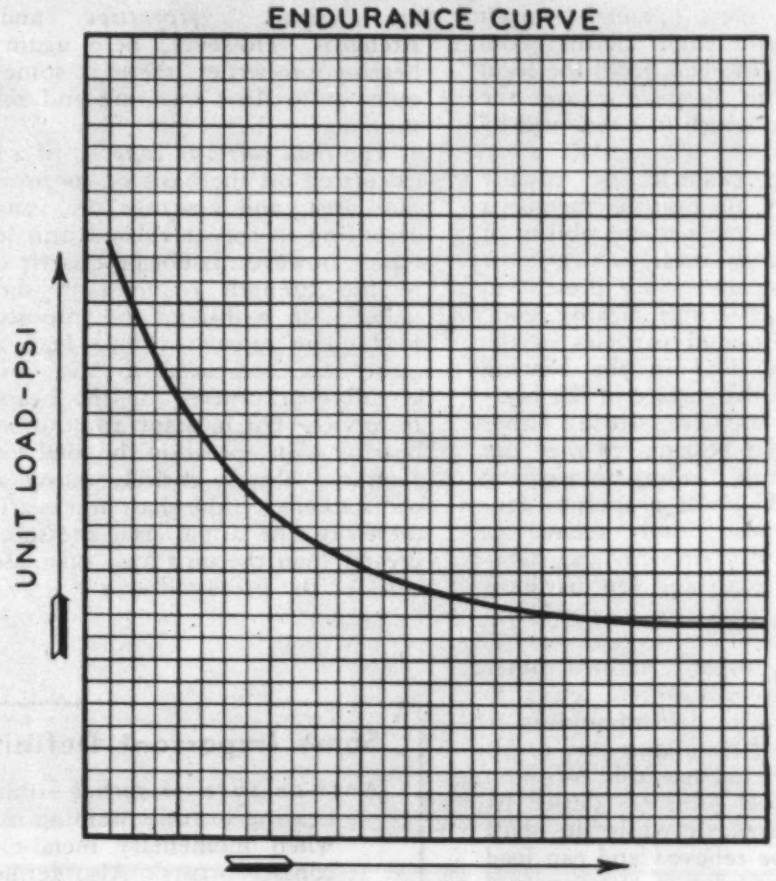
The fatigue strength or fatigue life of a bearing metal is significantly influenced by the unit load. It is well known that within certain limits bearing life increases with a decrease in unit load; or conversely, shorter expected life allows heavier bearing loads.

As is generally true in considering fatigue of metals, the greater the strength of the bearing metal at operating temperatures the greater the fatigue strength. And as is also true with most metals, high ductility in the bearing metal does not necessarily indicate high fatigue strength.

In general, bearing applications involve only small or moderate impact loads. Therefore, impact strength is usually not a major consideration except in cases where the bearing is subject to pounding, such as is encountered in rock crushing machinery, or certain types of rolling equipment. Impact stresses, however, do affect fatigue life, and it is from this standpoint that it requires consideration. For example, in one case changing from aluminum to cast iron pistons resulted in additional weight on the bearings with an average increase in impact load of about 10%, which significantly affected the fatigue life of the bearings.

When a bearing metal is bonded to a back-up material, *bondability* is another consideration. The strength of the bond depends on a number of factors, including the composition of the bearing metal and back-up material, the joining or "tinning agent," if used, and the manufacturing technique. Since the principal reason for bonding the bearing metal to another metal is to improve strength properties, bondability is most often directly related to and inseparable from the strength and load carrying capacity of the bearing.

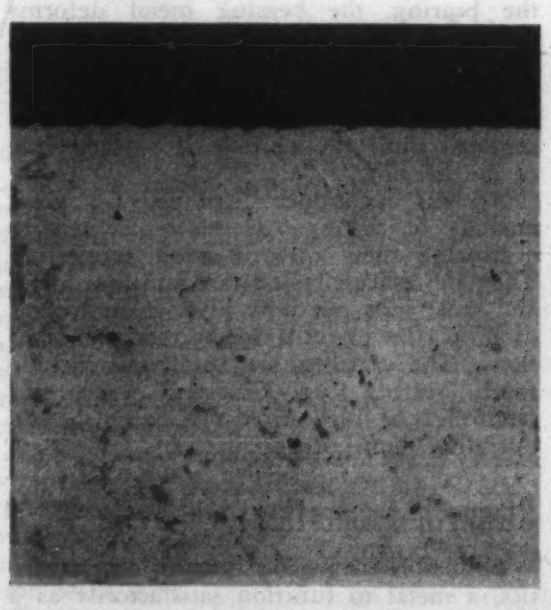
Finally, in the review of factors affecting the performance of bearing metals, we must



Relation between bearing life and unit load. (Courtesy: Cleveland Graphite Bronze Co.)

Below are shown a number of microphotographs illustrating the typical bearing constructions. (Courtesy: Cleveland Graphite Bronze Co.)

Conventional steel-backed babbitt. Top, 0.020-in. babbitt; bottom, steel back.



Thin babbitt overlay on steel back. Top, 0.002- to 0.007-in. babbitt; bottom, steel back.

Three-layer composite type. Top, 0.001- to 0.006-in. babbitt; center, leaded bronze or copper-lead; bottom, steel back.

Bearing Metals

Properties and Characteristics of Bearing Metals

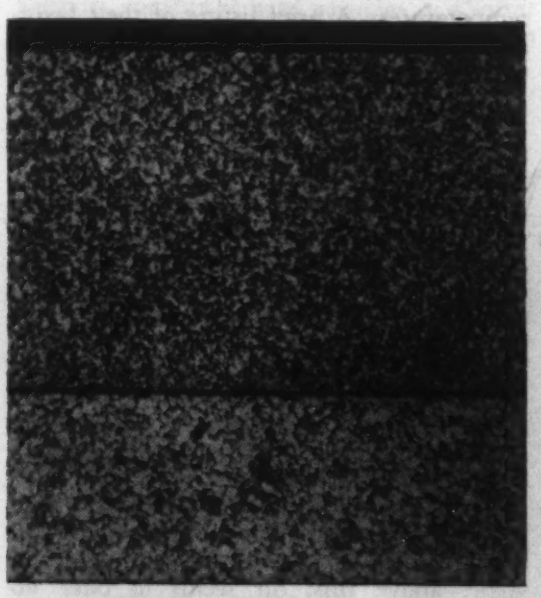
Bearing Metal	Hardness Room Temp. Brinell	Hardness 300 F Brinell	Min. Shaft Hardness Brinell	Load Carrying Capacity, Psi.	Max. Operating Temp. F	Fatigue Strength	Anti-Seizure	Conformability & Embeddability
Tin-Base Babbitt	20-30	6-12	150 or less	800-1500	300	*3	1	1
Lead-Base Babbitt	15-20	6-12	150 or less	800-1200	300	3	1	1
Alkali Hardened Lead	22-26	11-17	200-250	1200-1500	500	3	1	1
Cadmium Base	30-40	15	200-250	1500-2000	500	3	1	1
Copper-Lead	20-30	20-23	300	1500-2500	350	2	2	2
Tin Bronze	60-80	60-70	350-400	Above 4000	500+	1	3	3
Lead Bronze	40-70	40-60	300	3000-4500	450-500	1	3	3
Phosphor Bronze	75-100+	65-100	400	Above 4000	500+	1	3	3
Aluminum Alloy	45-50	40-45	300	Above 4000	225-300	2	2	3
Silver (Overplated)	25	25	300	Above 4000	500+	1	2	3
Copper-Nickel Matrix	10	7	150 or less	2000	350	2	1	2
Tri-Metal and Plated	Approximately the same as the babbitts		230	Above 4000	225-300	2	1	2
Grid Type			160-225	Above 4000	225-300	2	1	2
Thin Babbitt Overlay (0.002-0.007 In.)			150 or less	2000	300	2	1	2
Conventional Babbitt Overlays (0.020 in.)			150 or less	1500	300	2	1	2

This is an arbitrary scale with 1 being the highest rating.

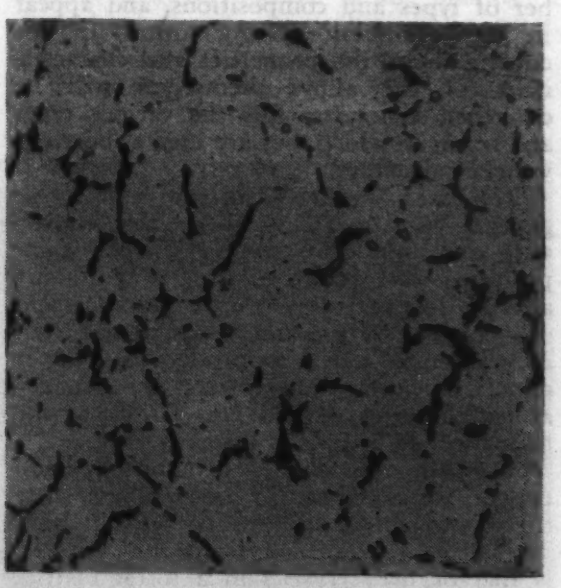
nsider *corrosion resistance.* For successful eration a bearing metal must resist at- k from lubricants likely to be used in the aring assembly. Some of these lubricating s oxidize to organic acids at temperatures ove 200 F and attack some metals. Cor- sion of the bearing surface can result in cessive wear, or in roughening of the rface leading to seizure and scoring. It n also change the surface properties of the metal and accelerate fatigue failure.

Thus far the effect of temperature on the performance of bearing metals has been touched on only briefly. Practically all bearings operate at above room temperatures; oil sump temperatures in automobiles go as high as 300 F; aircraft bearing temperatures reach at least 275 F. In general, the bearing and strength properties, and corrosion resistance are affected adversely by rising temperatures. However, there is some reason to believe that conformability and embeddability are improved somewhat. It is evident then that the properties of bearing metals at these higher temperatures are more important than their room temperature properties. Therefore, in evaluating bearing metals it is important to consider all the properties of the highest operating temperature.

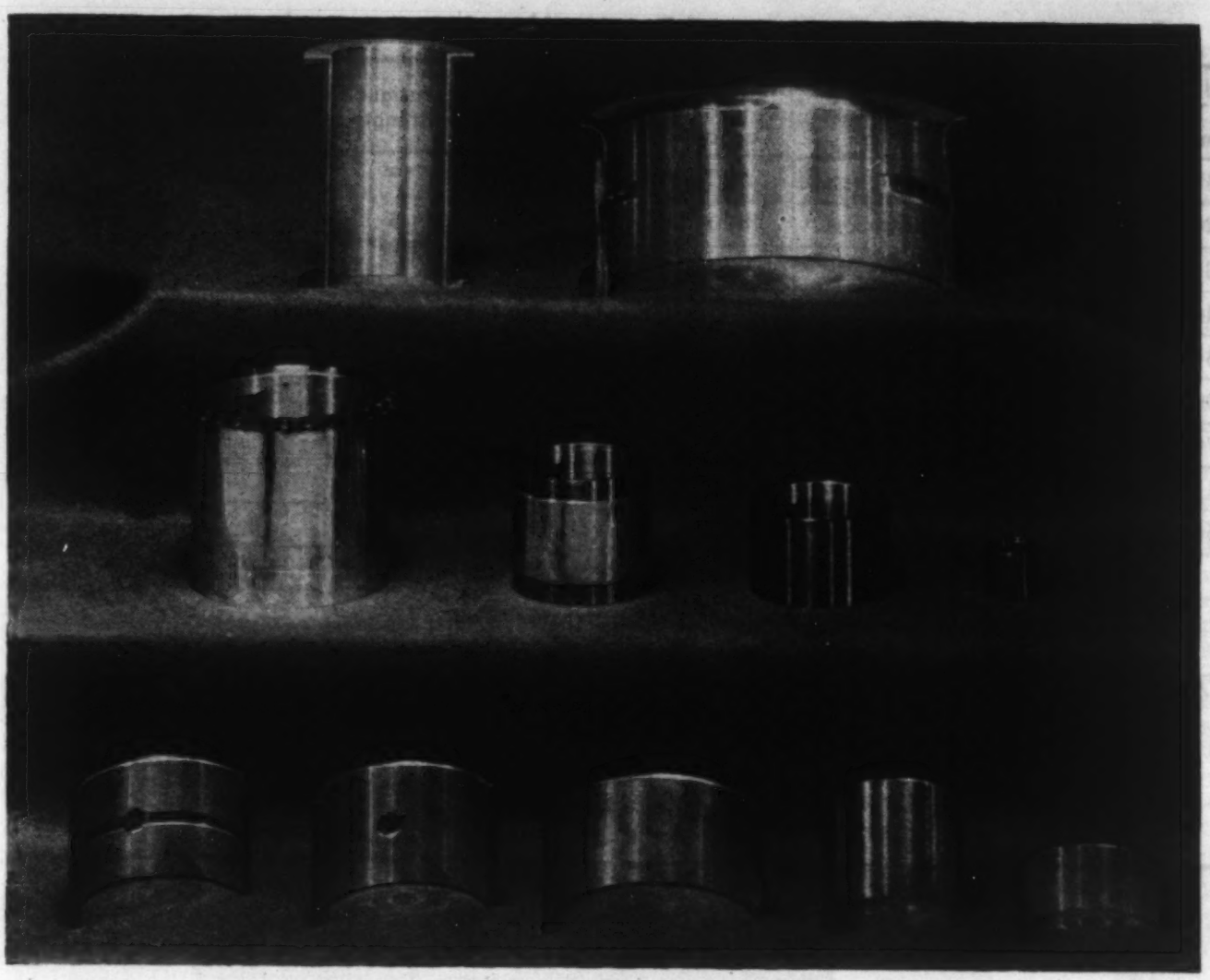
pper-lead on steel back. Top, copper-lead; bottom, steel back.



Silver bearing with overlay. Top, 0.0004- to 0.0010-in. plated lead; center, silver layer; bottom, steel back.



Aluminum alloy bearing, solid construction.



These represent some of the various forms of steel-backed aluminum bearings. (Courtesy: Al-Fin Corp.)

White Metal Alloys

The Babbitts

The group of alloys, commonly known as babbitts, are perhaps the best known of all bearing metals. They include a large number of types and compositions, and appear in many different bearing forms. In discussing them, the properties and characteristics of the alloys themselves will be described first; after this the various types and forms in which they are used as bearings will be taken up.

Tin-Base Babbitts—Tin-base babbitts in general contain 80 to 90% tin, alloyed with antimony and copper. Typical compositions range from 80 tin, 12 antimony and 7% copper to 92 tin, 4 antimony and 4% copper. Where conditions permit, lead is sometimes added to produce a cheaper alloy. However, lead lowers the strength at temperatures around 360 F due to the formation of a tin-lead eutectic.

The alloying elements, antimony and copper, are added to increase hardness, since tin alone has a hardness of only 7 Bhn. The structure resulting from this alloying is that of hard crystals in a softer matrix. The hard crystals are chiefly copper-tin needles and antimony-tin cuboids. The matrix consists basically of copper-tin and tin eutectics. The hard crystals contribute chiefly to the strength and raise the hardness of the alloys to about 32 Bhn.

Tin-base babbitts have excellent bearing properties, but they have low fatigue strength and fall off in strength at elevated temperatures. A brief listing of their favorable characteristics follows: (1) good wettability with lubricants, (2) high corrosion resistance in most oils at operating temperatures, (3) high embeddability and conformability, and (4) work well against soft shafts.

Lead-Base Babbitts—Lead-base babbitts contain 75 to 90% lead, the remainder antimony and tin plus, in some cases, small amounts of arsenic, bismuth, copper, nickel or silver. Typical compositions range from 75 lead, 15 antimony, 10% tin to 90 lead, 10% antimony. Lead alone, having a hardness of only 4 Bhn., is too soft for bearing applications, so the antimony and tin are added to increase hardness and strength. These properties are improved with antimony additions up to around 15 to 18%; beyond this amount the alloy tends to become brittle. Tin can be added up to around 10%; above this, tin seems to offer no decided advantage. With additions of these two metals, hardnesses close to 30 Bhn. are possible.

The structure of lead-base babbitts containing antimony and tin consists of hard, brittle antimony crystals, or tin-antimony crystals, or a combination of both in a tin-antimony-lead eutectic matrix.

Arsenic in amounts up to about 3% is frequently added to promote hardness and strength at operating temperatures. Two typical compositions are: 3 arsenic, 12 antimony, 1% tin, the balance lead; and 1 arsenic, 15 antimony, 1% tin, the balance lead. Fatigue tests on alloys of this type have shown them to be better than other lead-base babbitts and some tin-base babbitts in this respect.

Additions of nickel up to 1% or silver between 2½ and 5% also improved strength and hardness properties at elevated temperatures. Copper up to 2 or 3% increases hardness. Bismuth is often present in small amounts, but appears to add little to the properties, and if present in appreciable quantities, adversely affects hardness and strength at elevated temperatures.

The differences in performance between tin- and lead-base babbitts are not as clear-cut as they used to be. Formerly, tin-base alloys were always rated somewhat above lead-base babbitts. However, with the development of lead-base babbitts containing arsenic, or other elements such as nickel or silver, the service characteristics of the two

pes have come to be quite similar. Also, e use of thinner layers of bearing babbitts steel or bronze backs has improved the sition of lead-base alloys.

To briefly compare the characteristics both: lead babbitts containing arsenic or equivalent alloying elements) have gher strength than tin-base, with the two proaching each other at elevated temratures; tin-base babbitts are less susceptie to corrosion; both have about the same aring properties; finally, at present leadse babbitts are lower in price.

Graphitized Lead-Base—Another leadse bearing material reported to equal tinse babbitts in performance is known as raphitized lead. It is composed of lead ntaining 10% tin and hardened with pper, antimony, arsenic and cadmium. addition, it contains 0.02 to 0.04% of raphite by weight. During its manufacture raphite is added to the molten metal by special process which produces a perfect mixture and a homogeneous distribution the graphite throughout the metal. Upon peated remelting the constituents do not gregate and the graphite remains in colidal suspension.

This material has a room temperature rdness of 27 Bhn. and at 212 F a hardss of 13.0 Bhn. Its bearing and strength roperties are comparable to other leadse babbitts with the graphite in the loy as an additional lubricant to be conidered as a safety margin in cases where il lubrication runs low. In corrosion reistance it is also equal to other lead-base abbitts.

In general, graphitized lead is suitable r any applications within the range of e babbitt metals, and where the bearing apes are cast. It is not used in conjunction ith steel backs. Typical uses are: locomotive journal bearings, rolling mill bearngs and elevator shaft bearings.

Types and Characteristics—The babbitts a class are generally considered as the best earing material when used within their ad capacity range. They have excellent mbeddability, conformability and antieizure properties. They are suitable against ractically any hardness of steel shaft, alough as shaft hardness increases wear or anger of seizure decreases. Their cost comares favorably with other bearing metals, cept perhaps bronze. And with proper recautions their corrosion resistance is satisactory. But they are limited to unit loads f about 1000 psi., unless used with a backp material, and to operating temperatures f about 300 or 325 F.

In their simplest form babbitt bearings re cast solid either as full or half bearings nd bolted directly into the bearing housing. hey often run over 1-in. thick, depending n the application. In this type, mechanical onding involving dovetails or grooves is sed to anchor the bearing alloy to the hous-ng. Solid babbitt beatings are now limited n use to non-precision applications for eplacement in older equipment and in rge massive machinery.

For precision type sleeve bearings, with hich this manual is mostly concerned, abbitts are seldom used alone, but are nvariably placed on a back-up material of teel or bronze, to increase their strength roperties. Steel is most widely used for earing backs. Bronze is also used, particularly in aluminum housings, because its coefficient of expansion is closer to aluminum than is steel. However, bronze backs are more expensive than steel; also babbitt-to-bronze makes a more brittle bond than babbitt-to-steel.

In what might be called the conventional type of precision babbitt bearing, the thickness of the babbitt bearing alloy runs around 0.020 in. In thin overlay types, babbitt thickness ranges from about 0.002 to 0.007 in. Within this range decided improvement in strength is realized over thicker babbitt linings. Thus, conventional steel-backed babbitt bearings (0.020 in.) are generally rated as having a load capacity of up to about 1500 psi., while thin babbitt linings (0.002 to 0.007 in.) are rated at around 2000 psi. This improvement in strength also means longer bearing life for a specific bearing load. In some cases bearing life has been doubled by reducing the bearing layer thickness from 0.020 in. to 0.005 in.

Tests have been conducted to determine the effect of thickness of babbitt bearing alloys on bearing life. One set of tests was conducted under laboratory conditions with a mean calculated load of 2000 psi. and the results were substantiated in the field. It was found that in the range from 0.014 to 0.032 in. lining thickness had no effect on bearing life. But in the range from 0.005 to 0.014 in., wear life was increased from 50 hr. to over 150 hr. at a thickness of 0.005 in.

However, while strength characteristics are raised with thinner linings, conformability and embeddability are usually lowered. Therefore, more accurate assembly is required than with thicker linings. Several relatively new types of bearings have been developed which reduce this disadvantage. One of these makes use of an intermediate layer of good bearing properties between the steel and babbitt; another has an intermediate layer of sintered metal powder; and another is a grid type. These will be discussed later.

Alkali-Hardened Lead

The alloys in this group are composed of 95 to 98% lead, alloyed with calcium, tin and mercury, and are sometimes classed under babbitts. Their structure, similar to babbitts, consists of hard particles in a softer matrix; their mechanical properties at room temperature are of the same order as tin-base babbitts. The most common alloy of the group is called "Satco"; it contains about 2 tin, 0.50 to 0.75% calcium and traces of aluminum, and sometimes mercury and other metals. It has been used in railroad bearings and in many slow speed diesel engines. It is generally considered to more closely approach the performance of tin-base babbitts than do the lead-base alloys. The upper limit of temperature at which it can operate satisfactorily is about 500 F as compared to around 300 F for tin- and lead-base babbitts.

Alkali-hardened lead, however, is considerably less corrosion resistant than babbitts, and this limits its use to low-temperature applications if corrosive lubricants are used. Another short-coming is the difficulty involved in controlling the easily oxidized alkali elements during manufacture.

Cadmium-Base Alloys

Like hardened lead alloys, cadmium-base bearing alloys are occasionally grouped under babbitts because of their many similarities in structure and properties. Cadmium-base alloys commonly designated for bearing use have about 98% cadmium, alloyed with 1 to 1.5% nickel, or 0.40 to 0.75 copper and 0.50 to 2.00% silver. They are at least equal to babbitts in bearing properties and surpass them in hardness and strength characteristics. At room temperature their hardness runs around 35 Bhn. and at 300 F around 15 Bhn. Since cadmium alloys do not start to melt until about 600 F, the temperature range in which they can operate successfully is greater than with babbitts.

Their biggest advantage over babbitts is higher fatigue strength at elevated temperatures. However, they are very susceptible to corrosion by bearing lubricants. Therefore, there must be careful selection of lubricant. To get around this low corrosion resistance, cadmium alloys can be plated with indium, after which the bearing is heat treated to diffuse the indium into the surface. But this increases considerably the cost of an already expensive bearing. Despite their excellent properties, cadmium-base alloys are now seldom used. Cadmium is a critical and very scarce metal, making it both hard to get and prohibitive in price.

Main bearing scored by foreign particles. "A" indicates scoring by large chips dragged around by rotating shaft; "B" indicates "wandering" scores by smaller particles. (Courtesy: Federal-Mogul Corp.)

Copper-Base Alloys

This group of bearing metals, like the white metals, includes a large number of types and compositions. They range from the comparatively soft copper-lead materials to very hard tin-bronze compositions. As a class, they are generally rated lowest in bearing qualities, but are among the highest in strength and load carrying capacity. Therefore, except for copper-lead types, which approach the babbitts in properties, copper-base bearing metals are useful for heavy load applications, at relatively low speeds.

Copper-Lead

There are two types of copper-lead bearings. In both cases the copper-lead bearing material is placed on either a steel or bronze backing. The difference between the two lies in their metallographic structure and method of application to the back-up strip; this, in turn, influences the properties of the resulting product.

Cast Copper-Lead—The older of the two types is a mixture of copper and lead. The copper is present as a sponge-like structure and the spaces are filled with lead. Composition of the mixture runs about 70 copper and maximum of 30% lead. As lead content increases, segregation increases, and sometimes silver up to 5 or 6% is added to reduce this tendency. For a given composition, the structure may vary considerably in coarseness and uniformity, and this directly influences the bearing properties. Mixtures containing up to 24% lead are usually overplated with a 0.001-in. lead-tin layer. Those having around 30% lead may or may not be overplated.

Bearings of this material are prepared by casting the copper-lead mixture onto a back-up strip, if thickness of bearing lining does not exceed about 0.020 in. For heavier thicknesses the bearing is cast to shape.

Cast copper-lead bearings (not overplated) are rated close to the steel-backed babbitts. Their room temperature hardness, load carrying capacity and bearing properties are about the same as the babbitts. At 300 F the hardness, however, runs considerably higher, being about 20 Bhn. If about 1% tin is added, the hardness at 300 F rises to about 30 Bhn. In fatigue strength, cast copper-lead is rated above the babbitts.

In general, cast copper-lead is considered a good, long-wearing bearing metal where good bearing conditions are present and proper bearing design is used. But for successful performance it requires accurate fitting, hardened shafts of about 300 Bhn., good oil clearances, reliable lubrication, and non-corrosive oils.

Sintered Copper-Lead — To overcome some of the recognized disadvantages of cast copper-lead bearings, a sintered metal powder type has been developed. The copper and lead is produced in what is considered an alloy powder form. This powder is spread by a continuous process on a steel strip and then sintered. The result is a bearing material with a randomly oriented structure of a copper-lead alloy. The lead content is not limited because there is no danger of segregation. It is normally between 25 and 40%.

The greater range of lead contents possible and its alloy type structure makes sintered copper-lead more versatile than the cast type. By varying the lead content bearings for shafts of anv hardness can be produced. Greater bearing layer thicknesses by the continuous strip process are possible, and the bearing alloy can be placed on both sides of the steel back-up strip if desirable. Ductility, which is low in the cast type, is greatly improved so that bearings of almost any size can be formed without cracking the copper-lead lining.

Finally, corrosion resistance and fatigue strength may be considerably improved. In contact with corrosive lubricants, the lead (being present as isolated lakes in the copper matrix) is preferentially susceptible to attack in areas only near the surface. In the cast type, usually containing lead as continuous channels from bond to bearing surface, corrosion of the lead breaks down the lining structure more readily. Furthermore, the randomly oriented but uniform structure prevents premature breakdown in fatigue experienced by improper lead distribution occasionally found in linings of the cast type. Sintered copper-lead linings are somewhat softer after the lining is applied. However, forming and broaching operations produce a hardness generally comparable to the cast strip and cast tube type linings.

Bearing Bronzes

Bronze bearings were first composed exclusively of hard copper-tin compositions. Present day bearing bronzes more often than not contain some lead. Lead content may vary from 0 to as high as 30%. Variation in lead and tin content as well as small additions of other elements such as zinc, nickel and phosphorus, provides alloys with a wide range of bearing and strength properties. Thus, tin bronzes with little or no lead have high hardness and strength, but have lower bearing properties than the leaded bronzes. Leaded bronzes, in turn, are softer and of relatively low strength. Between the two extremes of tin and lead content there are a vast number of intermediate alloys whose characteristics and properties frequently overlap, and so it is difficult to make clear-cut comparisons. In many cases the properties are influenced more by the fabricated form and method of manufacture than by the composition.

The metallurgical structure of bearing bronzes is quite complex but does not depend entirely upon composition; other factors such as rate of cooling when cast may also influence the structure. The generally desired structure is one in which the copper and tin are alloyed to provide a hard delta eutectoid phase supported in a softer matrix of alpha crystals; the lead additions are distributed unalloyed throughout the structure. Thus, the harder constituents of the copper-tin alloy support the load, while lead lends plasticity to give the bearing more conformability and anti-seizure properties.

As a class, bearing bronzes are usually considered to be among the highest in fatigue strength and load carrying capacity under good service conditions of shaft alignment and reliable lubrication. Their range of use includes relatively small bushings for motors and small machinery as well as large bearings for such things as cantilever bridges.

Tin Bronzes—Tin bronzes are essentially copper-tin-zinc alloys with up to about 20% tin. A few percent of nickel or up to 10% lead is sometimes present. Those with practically no lead have room temperature hardnesses from about 60 to 80 Bhn., while those with lead can go as low as 50 Bhn. High tin bronzes have high mechanical properties; they are rigid under load and are used for carrying heavy loads at moderate speed. Since their bearing properties are low, they require accurate shaft alignment, reliable lubrication, and a minimum shaft hardness of 300 to 400 Bhn., depending on the hardness of the bearing. Tin bronzes will carry unit loads up to 5000 psi. and higher.

Leaded Bronzes—Leaded bronzes have relatively low tin contents, up to 10%, and lead percentages running up to around 30%. They are softer than tin bronzes, ranging in hardness from 40 to almost 70 Bhn. at room temperature, and therefore do not have as high strength properties. Their load carrying capacity is also lower, being anywhere from 4000 to 5000 psi.

As temperature rises, leaded bronzes lose strength more rapidly than tin bronzes, due to weakening of the lead between the copper-tin grains. However, there are leaded bronzes available in which a deliberate effort is made to have the lead appear within the copper-tin boundaries. The strength of such leaded bronzes is reported to fall off less rapidly than other lead bronzes.

Although the minimum shaft hardness on which leaded bronzes can operate runs between 200 and 230 Bhn., depending on the lead content, a minimum of 500 Bhn. is preferred. Lead-bronze alloys in general will not operate satisfactorily at temperatures above 450 to 500 F. At these temperatures the lead constituent tends to bleed from the alloy.

The relative high lead content makes leaded bronzes somewhat plastic in nature and, therefore, they do not require as accurate shaft alignment as the tin bronzes. In anti-seizure and embeddability properties they are also rated above tin bronzes.

Leaded bronzes with higher lead content are susceptible to corrosion from dilute organic acids that result from the deterioration of some bearing lubricants. However, small additions of nickel or of nickel and silver modifies this limitation.

Phosphor Bronze—These bronze alloys are similar in composition to tin bronzes, except that they are deoxidized with phosphorus. Phosphorus content can run to around 1%. Their use is confined to a small field of applications where extremely heavy loads at low speeds are encountered. Because of their high hardness, which is frequently over 100 Bhn., a fully hardened shaft very accurately aligned must be used; also, lubrication must be ample and reliable. Because of these limitations phosphor bronze is confined to very heavy load applications where no other material can do the job.

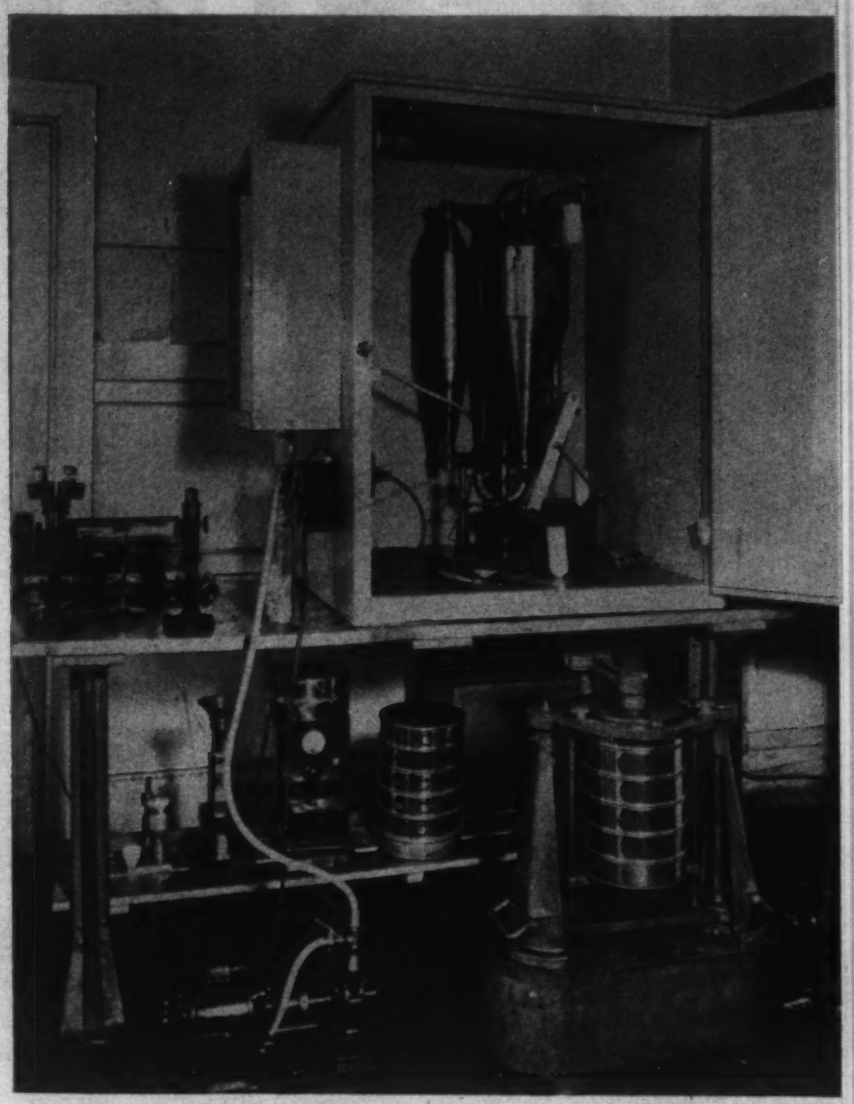
Types and Forms of Bronze Bearings—As was mentioned previously, bearing bronzes are used in a variety of forms and are fabricated into bearings by a number of differ-

ent methods which influence significantly their service performance. Solid full bearings are produced either by sand casting, permanent mold casting or centrifugal casting methods. Centrifugally cast bronze bearings have higher strength properties while still maintaining bearing properties comparable to those found in sand cast and permanent mold cast bushings.

Where large quantities of small size bearings are required, solid thin walled bronze bearings are produced from sheet stock by a series of stamping and forming operations. They are lower priced, and have as good properties as many cast bronzes. Cast and sheet metal type bronze bearings can be graphited when they are to be used in locations that are inaccessible for lubrication. In this type of bearing, the bronze alloy is grooved or indented and graphite inserted in the spaces under heavy pressure.

Steel-backed bronze bearings are produced in much the same way as sintered copper-lead bearings described earlier. Bearing bronze in powder form is placed on continuous strip steel and sintered in an atmosphere furnace; it is then cut and formed into the desired bearing shapes. In this form the bronze bearing material is ductile and allows the bearings to be used where an appreciable amount of shock or pounding is encountered. Leaded bronze compositions with some tin are generally used; a typical composition is 80 copper, 10 lead, 10% tin. These powder metal bronze bearings can also be graphited. Graphite powder is mixed with the bronze powder prior to bonding to the steel strip.

Bearing Metals



For optimum bearing performance, production is carefully controlled. Here is an outfit for determining specific gravity of porous bearings to insure uniformity of strength and porosity. (Courtesy: Bound Brook Oil-Less Bearing Co.)

Aluminum Alloys

In recent years aluminum alloys have received wide attention as bearing metals both in this country and abroad, and many different compositions have been proposed. At present there are three major alloys in use. The nominal composition of one is: 6.5 tin, 1 nickel, 1% copper, the balance aluminum. The composition of another is: 6.5 tin, 2.5 silicon, 1 copper, 0.5% nickel, the balance aluminum. And a third alloy is composed of 4% each of silicon and cadmium, with the balance aluminum. The structure of these alloys consists of a matrix of aluminum throughout which is dispersed undissolved constituents. Since their properties and characteristics are sufficiently alike, all three alloys can be considered together.

The anti-seizure properties of aluminum bearing alloys are generally considered to be about equal to babbitts; in embeddability they are about equal to copper-leads. The alloys have excellent corrosion resistance against the organic acids which are formed from the decomposition of lubricating oils. In tests they have proved equal to silver and definitely superior to tin babbitt and copper-lead. Pure aluminum has good thermal conductivity, and even though it is reduced somewhat by the alloying elements, it still compares favorably with other bearing materials except silver and grid type bearings.

Aluminum-bearing alloys have two recognized disadvantages. One of these is a high coefficient of expansion as compared to steel, and the other is low fatigue strength. The high coefficient of expansion introduces the factor of mechanical stability which is usually not a serious consideration with other bearing materials. When solid aluminum bearings are installed in cast iron or steel housings, this high coefficient of expansion results in thermal compressive strains being set up which are added to the strains imposed by the bearing load. Therefore, compressive strength is an important consideration and it must be high enough to resist deformation caused by these additive factors.

The present fatigue strength of aluminum-bearing alloys could probably be improved by more alloy additions, but, unfortunately, the anti-seizure properties would be seriously impaired. Therefore, the approach has been to bond a thin layer of the bearing alloy on a heavier steel backing. By doing this the fatigue strength is considerably improved and the coefficient of expansion problem is eliminated. At the same time the bearing properties remain essentially the same.

Two methods are used in fabricating steel-backed aluminum bearings. In one of these the aluminum alloy is cast on the specially prepared inside surface of steel tubes. If desired the outside can also be covered. These shells are then machined and used as rounds or split for the manufacture of bearing halfs. In the other method, the aluminum-bearing alloy is bonded to the steel in strip form and then formed from the flat stock by usual forming methods. With this method, either one or both sides can also be covered by the bearing material.

Solid aluminum bearings despite the limitations already mentioned are finding use in heavy duty applications such as automotive and aircraft engines. With proper design they have provided a service life of several thousand hours at loads up to 4000 psi.; in some cases satisfactory performance has been recorded for loads up to 6000 psi. At lower loads, 2000 to 3000 psi., they have had longer life than babbitt, copper-lead, and cadmium-lined bearings. For successful operation, however, solid aluminum bearings should have high running clearances, reliable and clean oil supply, and hardened shafts. In general, they are not satisfactory at operating temperatures above 225 to 250 F.

Steel-backed aluminum bearings have proved to be particularly applicable in installations requiring thin wall bearings, and also where bearing temperatures are too high and would cause solid aluminum bearings to exceed their yield strength. The fatigue strength and general bearing performance of the steel-backed type closely approaches silver bearings.

Most thin backed bearings are made by a continuous production line process, such as shown here. (Courtesy: Cleveland Graphite Bronze Co.)

Three-Layer Composite Bearings

It was pointed out previously in the discussion of backed babbit bearings that although strength properties increase with decreasing thickness of the bearing layer, there is a limit to which this thickness can be reduced because of the consequent lowering in conformability and embeddability. Several types of bearings have been developed in recent years to overcome this limitation and to allow a further reduction in the thickness of babbitt overlays. All of them involve (1) a steel or bronze backing, (2) an intermediate layer to provide additional strength and improved bearing properties, and (3) a very thin overlay of babbitt.

Copper-Nickel Matrix Type

This type has a steel-back and a high lead-base babbitt bearing overlay supported by and bonded to a porous (or sponge-like) metallic intermediate layer. The bearing overlay is an alloy containing 4 tin, 3 antimony and 93% lead. Its thickness is held to between 0.0005 and 0.003 in. The intermediate supporting layer or "matrix" is a copper-nickel alloy, and the steel backing is SAE 1010 steel.

The bearing material is produced by a continuous strip process. A mixture of 60% copper powder and 40% nickel powder, by weight, is deposited on the steel strip and passed through a sintering furnace. The copper alloys with the nickel and brazes to the steel strip. The strip then passes through a special vacuum casting machine where babbitt is cast on the matrix and penetrates into the pores.

There are several functions performed by the copper-nickel intermediate layer. It provides increased bonding area for the babbitt as well as both a mechanical and metallurgical bond, thus improving the fatigue strength of the bearing. It acts as a support for the babbitt and improves the conformability and embeddability characteristics. Another advantage claimed for this type bearing is that it permits the use of a more ductile babbitt, which results in greater fatigue strength.

Under normal conditions the load carrying capacity is around 2000 psi., or about a 15 to 20% increase over conventional lead-base babbitt bearings. The material is corrosion resistant to normal acid conditions arising from oxidation of bearing lubricants. These bearings are being used in automotive connecting rods and main bearings, and in full-round split-type bushings for camshaft bearings.

Tri-Metal and Plated Types

These bearings can have either a steel or bronze back, but steel is by far the most widely used. The intermediate layer is either a copper-lead composition or a leaded bronze, and is usually about 0.013 in. thick. This middle layer is machined to finished bearing tolerance in preparation for the precision overlay. The overlay is a babbitt composition which is plated or cast to a thickness of as thin as 0.002 in. or less.

A typical composition for the intermediate layer is 80 copper, 10 tin, 10% lead. The function of the intermediate layer is similar to that of other composite bearings. While

the thin precision overlay provides a surface with excellent bearing properties, the middle layer supports the bearing material and increases its strength and endurance properties. In some cases it also allows a softer shaft to be used. When a copper-lead intermediate layer is used, for example, the shaft hardness may be as low as 235 Bhn. The load carrying capacity of these bearings is reported to be from 3000 to above 4000 psi., depending upon composition and operating conditions.

Grid Type

The manufacture of grid type bearings consists of bonding an intermediate layer to a steel backing, then knurling this layer to provide indentations, which are later filled with lead or a lead-base babbitt. The intermediate layer of copper alloy or silver is applied to the steel by either casting or electroplating. The bearing layer is also applied by casting or electroplating. The surface is then machined so that the final structure consists of the intermediate layer with a grid work filled with a lead bearing alloy. The gridded area is generally 25 to 60% of the total area, and the depth of the indentations is approximately 0.020 in. The steel backing is usually a low carbon steel, while the bearing layer is usually lead-base babbitt with a 5 to 10% tin. Although other babbitt compositions can be used, they should have good bearing and noncorrosive properties. The intermediate layer is frequently a centrifugally cast lead bronze.

In general, gridded bearings rate as high as babbitts in bearing qualities; the gridded area provides conformability and embeddability, not possible in conventional bronze bearings, and also allows operation on softer shafts. In some cases they are operating on shafts with a hardness of 160 Bhn. Because of the strong intermediate layer they are rated among the best in fatigue strength and load carrying ability. In corrosion resistance they are equal to practically all other bearing materials.

The principal disadvantages to their wide use at present is their high cost. Also, they are generally limited in size to a minimum of around 3-in. bore dia., although some have been made less than 1 in. in dia. At present, grid type bearings are being used in some diesel applications for connecting rod bearings where loads of around 4000 psi. are encountered.

Silver Bearings

Although silver alone as a bearing surface has given good results in some applications, it is seldom used without an overlay, because of its erratic anti-seizure characteristics. The present day silver bearings, therefore, consist of three layers: a steel strip backing, an intermediate layer of silver, and a lead-base alloy overlay which is generally treated with indium. Latest practice is to electrodeposit the silver on top of a very thin copper or nickel flash. After plating, the silver is annealed at 1000 F. It is then machined to finished tolerances, after which a coating of lead, 0.0004 to 0.0010 in., is electroplated over the silver surface. Lead, however, is soluble in organic compounds which are present in bearing lubricants or which are formed at elevated temperatures. Therefore, a flash coating of indium is plated on the lead and then given a heat treatment which diffuses it into the underlying coat. In addition to preventing corrosion, this indium treatment is believed to make the lead plate bearing harder and tougher and also increase its wettability.

Silver bearings are generally considered to be the ultimate in bearing materials. Silver alone does not rate this compliment, because in bearing properties it is inferior to the babbitts. However, in combination with the lead-base overlay it does provide an excellent bearing for high load, high-speed applications at both low and elevated temperatures.

The fatigue strength of silver bearings is considered to be higher than any other bearing material. They are also highest in load carrying capacity. In many laboratory tests they have operated successfully at loads in excess of 10,000 psi. Three properties of silver probably contribute most to these excellent strength characteristics: (1) it is very ductile and can operate successfully under repeated stresses; (2) because of its high thermal conductivity, the heat created at hot spots is quickly dissipated; and (3) it has a hardness of about 25 Bhn., which is retained at elevated temperatures.

In bearing qualities, silver bearings closely approach the babbitts, except in embeddability. Silver itself does not have the ability to absorb dirt or grit; the lead overlay compensates somewhat for this low embeddability, but nevertheless, silver bearings require rather clean operating conditions.

Although silver bearings are rated highest among bearing materials, they are not suitable for all bearing applications. Their low embeddability restricts them to uses where cleanliness is assured. Their biggest limitation, however, is cost. With silver costing over $10 per lb., it is obvious that silver bearings are only used where no other bearing material will function satisfactorily.

Other Bearing Metals

Porous Metal Bearings

Porous metal bearings are made of sintered metal powders and are impregnated with oil to make them self lubricating. They are usually a 10% tin-bronze with up to 1.5% graphite. They are manufactured by regular powder-metallurgy techniques. The metal powder ingredients are mechanically mixed, pressed into shape, and sintered to form a bronze alloy structure. The parts are then impregnated with oil, finish sized, and then submerged in oil again. They usually hold up to about 30% of their volume in oil. In operation the oil in the bearing seeps from the pores and forms a continuous oil film on the bearing surface and prevents metal-to-metal contact.

Porous bronze bearings have found wide acceptance for high-speed, light load applications where the bearing can build up a satisfactory oil film. They are not in a class with most of the other precision bearings materials discussed in this manual. The great bulk of their applications is as auxiliary bearings in such things as automobiles and electrical appliances of all kinds. The majority of these applications have bearing loads ranging up to 50 psi. While porous bearings are used in some applications involving heavier loads, they are not common. Under static conditions or very slow movement, the load capacity can be as high at 4000 psi.

The hardness of porous bronze bearings is comparable to cast bronze if microhardness is considered. However, because of their porous nature, the general or overall hardness is considerably lower. With light loads almost any hardness of shaft is satisfactory, but at loads above 50 psi. hardened and ground shafts are required.

The corrosion resistance of these bearings is comparable to regular 10% tin-bronze. They can perform satisfactorily up to around 250 F. If graphite powder is added to the composition, the maximum temperature is raised to 500 F for light loads. Within their proper field of use, porous bronze bearings are considered about equal to babbitts in embeddability and anti-seizure characteristics, but lower in conformability.

Porous bearings can also be made of iron powder with or without additions of copper. Their use is generally limited to very slow speed or static load applications involving shock. Their strength and shock resistance is much higher than bronze, but their bearing properties—particularly anti-seizure—is quite low.

Cast Iron

Cast iron has from time to time been considered as quite a good bearing metal, but at present its use is very limited. Cast iron bearings have performed satisfactorily at very low speeds; there are also cases reported where they have been successful at high speeds under certain ideal conditions. Nevertheless, with its poor anti-seizure qualities cast iron has a tendency to seize suddenly; and even the seizure of one small particle or area often leads to breaking out of larger areas, leading to complete destruction of the bearing.

Zinc-Base Alloys

Although much work has been done abroad on zinc-base alloys for bearing applications, only a limited amount of development work has been performed in this country. However, several zinc-base alloys have been used for a number of years for bushings in high-speed, light load applications or very slow speed, light load ap-

plications. One of these, known as "Lumen" bronze, has 86 zinc, 10 copper, 4% aluminum. This alloy has a hardness around 120 Bhn. and a high compressive strength, but is quite brittle. It sees use for electric motor bearings and in heavy equipment such as cranes and swing bridges.

The regular zinc die casting alloys containing up to several percent aluminum and copper can also serve as bearings under certain conditions. They have given successful performance under loads of about 250 psi. where the following conditions were met: ground steel shaft, machined bearing surface, positive lubrication, shaft speed greater than 200 rpm., good alignment, and clearance of approximately 0.002 in. for a ½-in. shaft. In applications where any of the above conditions cannot be met, and the shaft speed is less than 200 rpm., the bearing load cannot exceed 50 psi.

Cemented Carbide

One of the recent developments in the sleeve bearing field is that of using cemented carbide as a bearing alloy. It shows promise as a sleeve and disk thrust bearing material. Laboratory development work, substantiated by some field testing, indicates that there may be considerable advantage in the use of this material. The high moduli of elasticity and rigidity of this material, together with the relative ease of obtaining good surface finish, provide a potential bearing material capable of successful operation at high or low speeds and loads. When carbide is operated upon carbide, small diametral clearances as low as 0.0001 in. are possible, making available a sleeve bearing for use in precision equipment, using light spindle oil, kerosene or water as the lubricant, either as a liquid or in the form of a mist.

Graphite-Metal

It was mentioned elsewhere that graphite is sometimes used in metal bearings to assure adequate lubrication in inaccessible locations. In these bearings the graphite is placed in surface grooves and indentations, or as in the case of powdered metal bearings, it is mixed with the metal powders. There is another type which has a graphite base. The graphite is in solid, molded form and impregnated with molten metal. The bearings are approximately 45% metal and 55% graphite by weight. The metals that are used include lead-base babbitts, copper, leaded bronze, cadmium, and silver. These bearings find use where normal lubrication cannot be applied, particularly in equipment where high temperatures would break down ordinary oil lubricants. Copper or silver impregnated graphite bearings will operate at temperatures up to 700 F.

Selecting the Bearing Metal

In any given bearing application selecting the best bearing metal for the job can be fairly simple and obvious or it may require a lengthy and rather complex analysis, depending upon the particular conditions involved. And like all materials-selection problems, choosing the right bearing metal is always a compromise. While it is desirable to get a bearing that will meet completely all requirements, it is usually found that there is no such ideal bearing metal, and that sacrifices must be made of some properties to gain others.

In most cases it will be found that in selecting a bearing alloy for a particular application many factors must be taken into consideration. Perhaps foremost is life expectancy. If a bearing assembly is not expected to operate longer than several hundred hours, the bearing selection is likely to be quite different than for a comparable part which is designed to operate satisfactorily for several thousand hours.

It is necessary, then, to pick the lowest cost bearing metal that will most closely meet the life expectancy requirements. And this requires careful consideration of the service and operating conditions, which include the amount and kind of bearing load, the shaft speed and kind of motion, operating temperatures, bearing lubricant and cleanliness of the lubricating system, and whether or not the bearing must operate in contact with corrosive agents.

Besides this variety of service and operating conditions, there are a number of installation or design factors that must be considered. Some of these include type, hardness and finish of the shaft material; the kind of material used in the housing; and running clearances and various tolerances that must be met. All these and many more variables are encountered. A check list of them is given in an accompanying chart.

The main purpose of this manual was to give a broad view of the many and diverse bearing alloys that are available. Obviously, it could not give all the information needed to make final selections of bearings for specific jobs. That requires consultation with bearing manufacturers. They are experts in their field and are prepared to help choose the bearing that will do the best job.

Check List of Selection Factors

Here is a typical report blank used by bearing manufacturers to obtain the data necessary to select the proper bearing for any particular job.

Type of machine in which bearing is used.....
Function of bearing .....
Number bearings per unit.....
What are bearing dimensions?.....
Housing bore (include tolerance).....
Housing materials.....
What is running clearance, original.....Maximum.....
Shaft material.....Hardness.....Surface finish .....
Shaft diameter (include tolerance).....
Total load on bearing.....
Maximum bearing unit pressure (psi. projected area).....
Application of bearing load: (1) Constant.....Shock.....Intermediate.....
(2) Constant direction..... Rotating around bearing.....
Shaft motion: Rotating.....Oscillating.....Sliding.....
Shaft speed: (1) Ft. per min. surface speed.....(2) R.P.M.....
Type and grade of lubricant.....Temperature.....
Type of lubrication: Pressure.....Splash.....Oil ring.....Wick.....
Reservoir.....Other: .....
If lubricant is not oil, how is it introduced into bearing?.....
.....
Type oil filter.....Type of oil seal.....
Does lubricant become contaminated?.....If so, with what.....
How many hours per year is bearing in operation?.....
Expected life for this bearing application.....

Acknowledgment

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Federal-Mogul Corp.
Federated Metals Div., American Smelting & Refining Co.
Graphite Metallizing Corp.
Graphitized Alloys Corp.
Johnson Bronze Co.
Lumen Bearing Co.
Moraine Products Div., General Motors Corp.
National Bearing Div., American Brake Shoe Co.
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MATERIALS & METHODS **Engineering File Facts**

NUMBER 164
August, 1948

MATERIALS: Engineering Steels
METHODS: Cutting

Flame Cutting of Ferrous Metals

Methods

Oxyacetylene Process—This is the most common and most widely used method for cutting ferrous metals. Oxygen and acetylene gas pass through a torch under pressure to a burner tip. The acetylene flame first preheats the metal at the starting point of the cut; then oxygen is released, it ignites, and cutting begins. The cutting action is caused by a rapid chemical reaction between iron and oxygen, forming iron oxide which melts away at a temperature below the melting point of base metal. The essential equipment includes: (1) a torch with a burner tip or nozzle and controls to regulate the flow of gas; (2) hoses connecting the torch with the gas supply; (3) pressure gages to indicate the pressure of the gases; (4) a supply of oxygen and acetylene. Oxygen must be relatively free from impurities: industrial or welding oxygen is of adequate (99.5%) purity.

Powder Cutting Process—This process is, in general, similar to oxyacetylene cutting. It is used for cutting high alloy steels and some nonferrous metals. The cutting is accomplished by using a finely divided iron-rich powder together with cutting oxygen to provide sufficient support to oxidation of the metal being cut. The powder is heated to ignition temperature by the oxyacetylene preheat flame. The powder is ejected into the oxygen stream and burns, creating a high temperature reaction. Refractory oxides that are formed when cutting high alloys are continuously removed by a combination melting and fluxing action.

Flux Cutting Method—This process resembles the powder cutting method just described. The important difference is that a chemical flux is used instead of an iron powder.

Oxyarc Process—In this process the metal is cut by a fine point concentration of heat generated by an electric arc and a stream of oxygen. A coated tubular electrode is used to produce either an a.c. or d.c. arc; a stream of oxygen is fed through the hollow electrode into the arc. This process can be used for cutting alloy steels (especially stainless steels), clad steels, nickel, nickel-copper alloys, copper alloys, aluminum and cast iron up to 3 in. thick (greater thicknesses can be cut but at lower efficiencies); thicknesses up to 12 in. can be pierced.

Cutting Techniques

Hand Cutting—The operator guides and moves his own cutting torch by hand. Sometimes the torch is held against straight or curved guides and traversed by hand; a hand torch equipped with a radius rod can be used for cutting circles with reasonable accuracy. Thicknesses of 8 to 12 in. may be cut (with fair accuracy) manually.

Machine Flame Cutting—Portable gas cutting machines are available for straight-line and circle cutting. The torches are guided by a template follower or tracing device. Large fixed machines are available with spans up to 144 in. and travelling on tracks so that their length of travel is almost unlimited. Carry up to 12 torches for the simultaneous cutting of up to 12 identical parts. High-speed tips may be used for machine cutting plate up to 8 in. thick with consequent increases in cutting speed of 15 to 25% (and with proportional decreases in the amount of gases used per foot of cut).

Cutting Thin Sheets—Thin sheets can be stacked and cut as one piece.

Accuracy of Cutting—Thicknesses up to 8 in. can be cut with considerable accuracy and smoothness. On thicknesses up to 6 in., the flame-cut surfaces have the same squareness and finish as do rough-machined parts. On 1-in. plate, the kerf may be 0.006 in. wider at the top than at the bottom; with 4-in. plate, this difference may go up to 0.035 in. Slabs and ingots up to 54 in. thick can be cut with an unaided torch. For large masses of steel, preheating between 200 and 800 F is often helpful.

Steels That Can Be Flame Cut (By Oxyacetylene Process)

Carbon steels containing up to 0.30% carbon can be cut with ease. Higher carbon steels require preheating to about 600 F. Manganese steels with up to 14 manganese and 1.5% carbon can be cut with difficulty after preheating. Silicon in the usual amounts has little effect on the cuttability of steel; 4% silicon transformer irons can be cut. Steels containing up to 5% chromium can be flame cut if their surfaces are clean. Higher chromium steels require a special technique—carburizing preheating flames are used and the resulting cut is rough.

Nickel up to about 7% has no adverse effect on the cuttability of the steel. Low carbon nickel steels (up to 20 to 30% nickel) can be flame cut.

Molybdenum affects the cutting of steel in the same manner as chromium.

Tungsten alloys up to 12 to 14% are readily cut; with higher tungsten contents, difficulty is encountered (about 20% tungsten is the limit). High molybdenum-tungsten steels require a special technique for cutting.

Copper less than 2% does not affect the cuttability.

Sulfur in small amounts has no effect; in larger quantities it reduces the cutting speed.

Phosphorus (within the usual commercial limits in steel) has no effect on the cuttability.

Vanadium in small amounts may improve the cutting qualities of steels.

(Continued on page 89)

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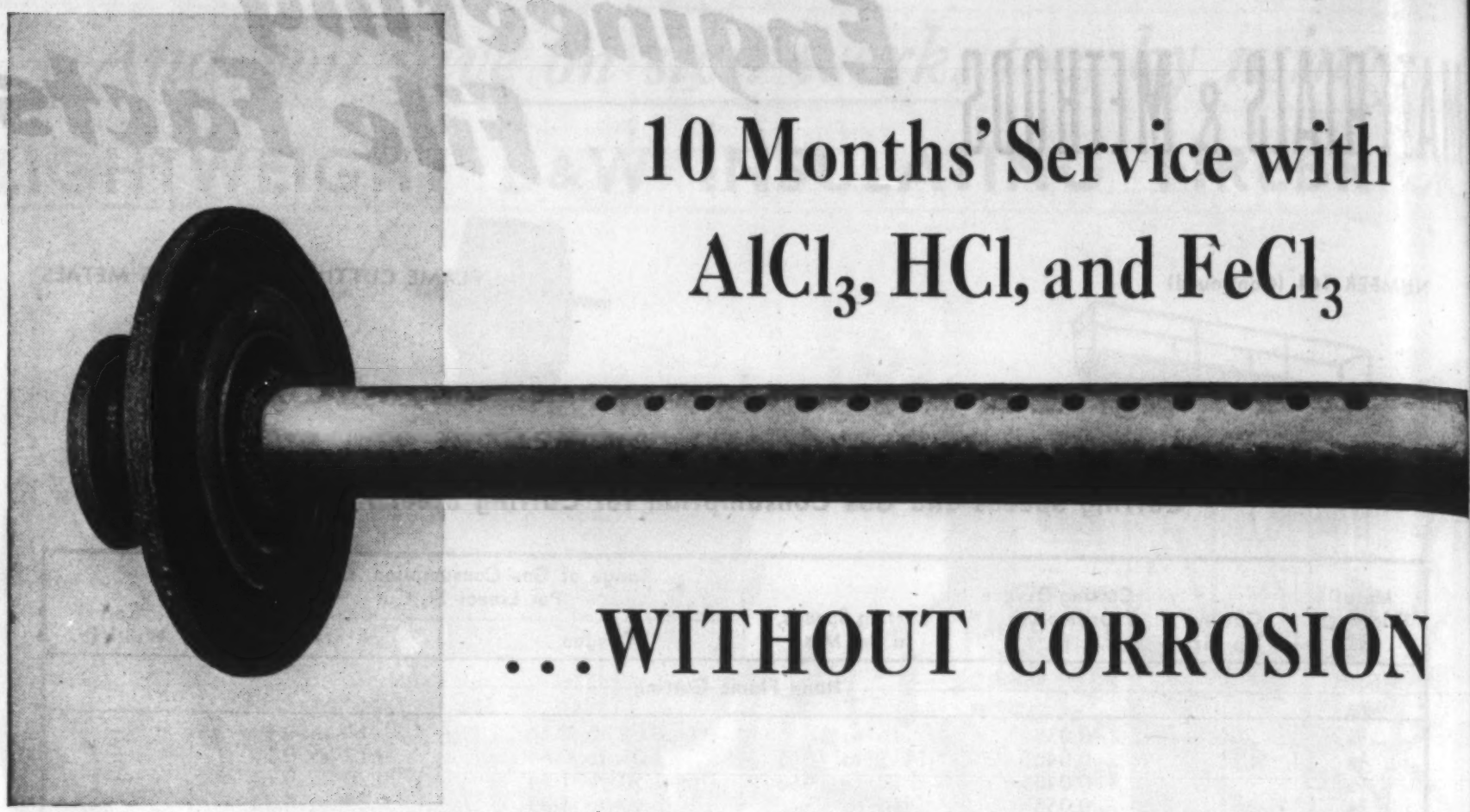
Cutting Speeds and Gas Consumption for Cutting Steel Plates

Metal Thickness, In.	Cutting Tip, Size	Cutting Oxygen Orifice Dia., In.	Cutting Speeds, In. Per Min.	Range of Gas Consumption, Cu. Ft. Per Linear Ft. Cut		Kerf Width In.
				Oxygen	Acetylene	
Hand Flame Cutting						
¼	0	0.038	16 to 18	0.63 to 0.56	0.11 to 0.10	—
⅜	1	0.0465	14½ to 16½	1.03 to 0.85	0.17 to 0.15	—
½	1	0.0465	12 to 14½	1.50 to 1.24	0.20 to 0.17	—
¾	2	0.055	10 to 13	2.40 to 1.85	0.28 to 0.22	—
1	2	0.055	8½ to 11½	3.29 to 2.44	0.33 to 0.24	—
1½	3	0.0635	6 to 7½	5.17 to 4.80	0.53 to 0.43	—
2	3	0.0635	5½ to 7	7.28 to 5.72	0.58 to 0.46	—
2½	4	0.073	5½ to 6½	9.09 to 7.69	0.62 to 0.52	—
3	5	0.082	5 to 6½	12.40 to 9.54	0.88 to 0.68	—
4	5	0.082	4 to 5	19.25 to 15.00	1.10 to 0.88	—
5	6	0.096	3½ to 4½	26.30 to 20.45	1.60 to 1.25	—
6	6	0.096	3 to 4	33.00 to 24.75	1.87 to 1.40	—
8	7	0.111	2½ to 3½	51.60 to 36.90	2.80 to 2.00	—
10	7	0.111	2 to 3	73.50 to 49.00	3.50 to 2.33	—
12	8	0.1285	1½ to 2	117.00 to 87.50	5.33 to 4.00	—
Machine Flame Cutting						
¼	0	0.038	20 to 24	0.50 to 0.42	0.09 to 0.08	0.075
⅜	1	0.0465	19 to 23	0.79 to 0.65	0.13 to 0.10	0.095
½	1	0.0465	17 to 21	1.06 to 0.86	0.14 to 0.11	0.095
¾	2	0.055	15 to 18	1.60 to 1.33	0.19 to 0.16	0.110
1	2	0.055	14 to 17	2.00 to 1.41	0.20 to 0.16	0.110
1½	3	0.0635	12 to 14½	3.08 to 2.55	0.27 to 0.22	0.130
2	3	0.0635	10 to 12	4.00 to 3.33	0.32 to 0.27	0.130
2½	4	0.073	9 to 11	5.55 to 4.55	0.38 to 0.31	0.145
3	5	0.082	8 to 10	7.75 to 6.20	0.55 to 0.44	0.165
4	5	0.082	7 to 8½	11.01 to 7.30	0.63 to 0.52	0.165
5	6	0.096	6 to 7	15.33 to 13.14	0.93 to 0.80	0.190
6	6	0.096	5 to 6	19.80 to 16.50	1.12 to 0.93	0.190
8	7	0.111	4 to 5	32.25 to 25.80	1.75 to 1.40	0.220
10	7	0.111	3½ to 4	42.00 to 36.80	2.00 to 1.75	0.220
12	8	0.1285	3 to 3½	58.30 to 50.00	2.67 to 2.29	0.260
14	8	0.1285	2½ to 3¼	62.50 to 48.00	4.40 to 3.38	0.260
16	9	0.147	2½ to 3	106.80 to 89.00	4.80 to 4.00	0.295
18	9	0.147	2½ to 3	130.40 to 108.70	5.20 to 4.33	0.295
Machine Flame Cutting (Using High-Speed Cutting Tips)						
¼	0	0.024	26 to 28	0.54 to 0.50	0.11 to 0.10	0.050
⅜	1	0.031	24 to 26	0.71 to 0.65	0.15 to 0.14	0.065
½	1	0.031	22 to 24	0.91 to 0.83	0.16 to 0.15	0.065
¾	2	0.036	20 to 22	1.20 to 1.09	0.18 to 0.15	0.075
1	2	0.036	18 to 20	1.45 to 1.30	0.20 to 0.18	0.075
1½	3	0.043	16 to 18	2.12 to 1.89	0.31 to 0.28	0.085
2	4	0.052	13 to 15	3.54 to 3.07	0.38 to 0.33	0.105
2½	4	0.052	12 to 14	4.08 to 3.50	0.42 to 0.36	0.105
3	6	0.0595	10 to 12	5.40 to 4.50	0.64 to 0.53	0.120
4	8	0.067	9 to 10	7.33 to 6.60	0.78 to 0.70	0.135
5	8	0.067	8 to 9	9.87 to 8.78	0.88 to 0.78	0.135
6	8	0.067	7 to 8	12.43 to 10.87	1.00 to 0.88	0.135
7	10	0.086	6 to 7	16.50 to 14.14	1.20 to 1.03	0.170
8	10	0.086	5½ to 6½	21.10 to 17.85	1.31 to 1.11	0.170

Data taken from "Steel Plates and Their Fabrication," published by Lukens Steel Co., and compiled by Robert S. Burpo, Jr.



10 Months' Service with $AlCl_3$, HCl, and $FeCl_3$ ...WITHOUT CORROSION

This sparger unit—made of HASTELLOY alloy C—is used to introduce gases into a catalytic reactor used in the production of styrene for polystyrene plastics and for synthetic rubber.

Machine marks are still visible on the sand-cast surface of this unit, although it has already been in service for over 10 months in contact with aluminum chloride, hydrogen chloride, ferric chloride, and hydrocarbon gases and liquids at temperatures of 240 to 270 deg. F. And it is expected to last indefinitely under these severely corrosive conditions. The unit previously used required replacement every three or four months at considerable expense and loss of time.

HASTELLOY alloy C is available in a variety of wrought forms and also as conventional or precision castings to meet your requirements. In addition to its excellent corrosion resistance, this alloy has high strength—even at red-heat temperatures—and it can be readily fabricated by most common methods. For more complete information, write for a copy of the booklet, "HASTELLOY High-Strength, Nickel-Base, Corrosion-Resistant Alloys," Form 3361.

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MATERIALS & METHODS

DIGEST

A selective condensation of articles — presenting new developments and ideas in materials and their processing — from foreign journals and domestic publications of specialized circulation.

Edited by H. R. CLAUSER

Gray Cast Iron as an Engineering Material

Gray iron properly used is a valuable engineering material. For its proper selection and use one must have a knowledge of the relationship between its composition and properties. Some helpful information on this subject was given in a paper on "Section Size, Hardness, Composition Relationship in Gray Cast Iron," by R. S. McElwee, before the *Society of Automotive Engineers* at their summer meeting early in June. In this paper McElwee reviewed the effects of various elements—particularly carbon and silicon—encountered in gray iron. He pointed out that until quite recently it was believed that carbon was incapable of close control. However, it has been found that carbon level can be quite closely controlled, and also that higher carbon levels have many advantages, including lower shrinkage and higher deflection. With proper adjustment of silicon, higher carbon level can also produce any reasonable strength and hardness.

Careful selection of carbon and silicon can easily affect economies of manufacture, both in the machine shop and the foundry. Higher total carbon involves higher graphitic carbon, which is responsible for better performance in applications involving heat resistance and wear resistance. In addition, by using high total carbon compositions the plastic or freezing range is shortened. And by narrowing this freezing period many casting difficulties, such as the possibility of microporosity, are eliminated. At the same time, the same matrix structure and hardness can be obtained at the higher carbon level as with lower carbon, provided silicon is adjusted properly in the opposite direction.

Because of an existing specification on Brinell hardness, it is sometimes difficult to substitute the more advantageous higher carbon unless the engineer is willing to modify Brinell hardness specifications. To indicate the fallacy of attempting to regulate the performance of an iron with respect to wear on the Brinell basis, an example is given. The iron used for this example, which was 4.00 total carbon, showed a Brinell hardness of 146, yet the microhardness of the pearlite between the graphite particles fell in the range of 226 to 255. This latter value is the load carrying value of the iron.

While this type of iron will show greater deformation under concentrated loads, it is an excellent material in those cases in which the unit pressures are well below the limit at which deformation begins. Records of high graphitic irons show many times the life, in resisting wear, of lower graphitic irons of the same matrix structure.

Welding and Die Casting Aluminum

The forming and fabrication of aluminum and its alloys has been receiving much attention in the foreign technical press, and here are brief reports on two articles that appeared recently in England in the *Metal Industry* magazine.

Welding of aluminum, in particular, is being widely discussed, probably because no really simple production method has been developed. An account of some interesting work to show that aluminum and some aluminum alloys can be cold-welded easily and reliably appears in the May 21, 1948 issue.

Cold-welding is done by pressure alone, this pressure being applied to the pieces to be joined by specially designed dies. The dies can be mounted in suitable hand tools, which are particularly useful for the thinner gages. Aluminum-to-aluminum and aluminum-to-copper welds so made have all failed around the weld and not across it.

There are two requirements for making satisfactory cold-welds: (1) The pieces must be treated to give perfectly clean, uncontaminated surfaces (no indication is given of this treatment in the article). (2) The pressure must be applied over a comparatively narrow strip so that the metal can flow away from the weld at both sides. This latter requirement imposes some restrictions on the form of the welds.

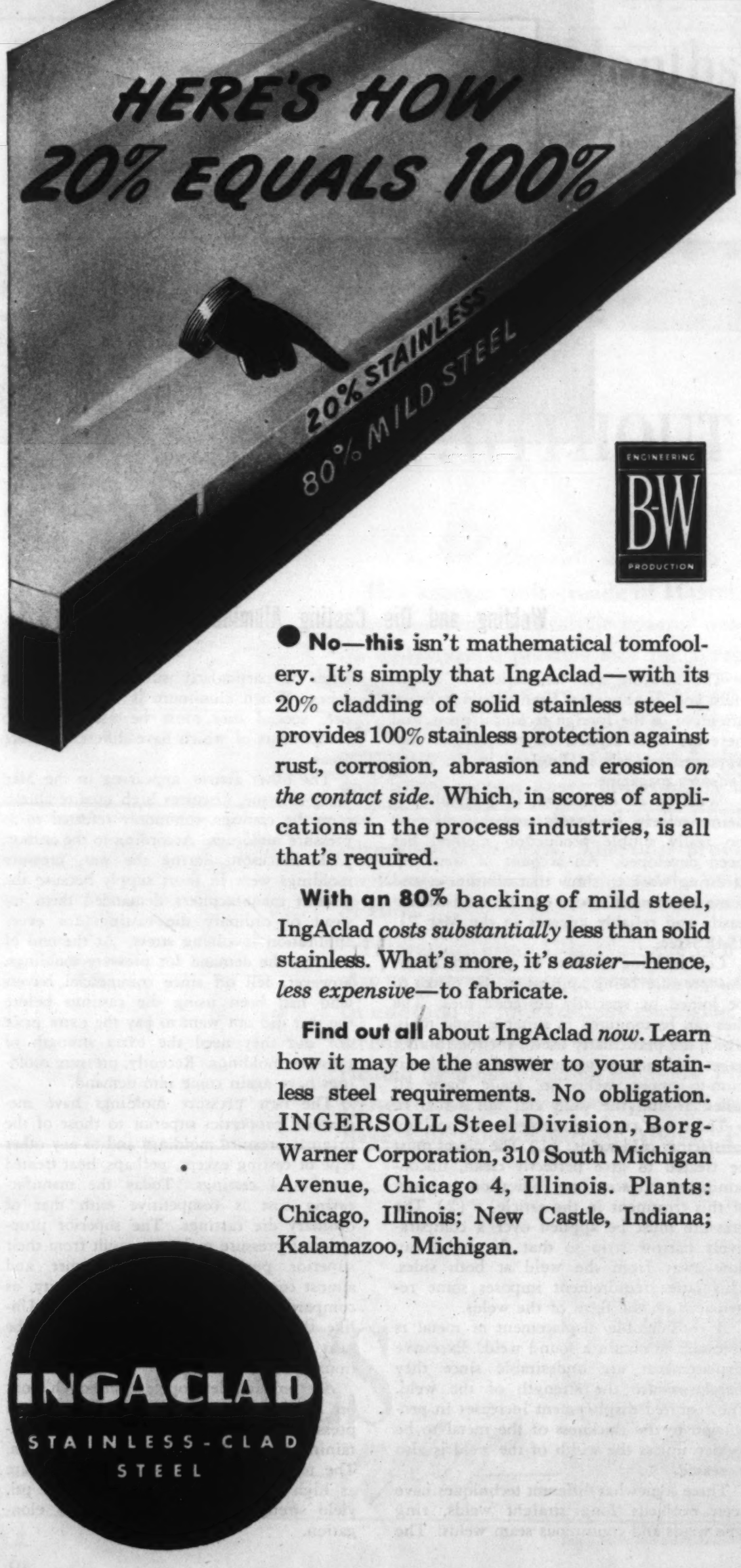
A considerable displacement of metal is necessary to obtain a sound weld. Excessive displacements are undesirable since they merely reduce the strength of the weld. The required displacement increases in proportion to the thickness of the metal to be welded unless the width of the weld is also increased.

Three somewhat different techniques have been evolved: long straight welds, ring type welds and continuous seam welds. The latter is particularly suitable for making tubes. When aluminum is welded to copper, special dies must be used, the two components of which have different surface areas.

The other article, appearing in the May 7, 1948 issue, discusses high quality aluminum die castings, commonly referred to as pressure moldings. According to the author, J. L. Erickson, during the war, pressure moldings were in short supply because the aircraft manufacturers demanded them instead of ordinary die castings for every application involving stress. At the end of the war the demand for pressure moldings, however, fell off since commercial buyers who had been using die castings before the war did not want to pay the extra price nor did they need the extra strength of pressure moldings. Recently, pressure moldings have again come into demand.

The new pressure moldings have mechanical properties superior to those of the original pressure moldings and to any other type of casting except, perhaps, heat treated centrifugal castings. Today the manufacturing cost is competitive with that of ordinary die castings. The superior properties of pressure moldings result from their superior purity and microstructure and almost complete freedom from porosity, as compared with ordinary die castings. Unlike the latter, pressure moldings may be heat treated without blistering and distortion.

A promising development, although work on it is not yet complete, is heat treated pressure moldings of aluminum alloys containing magnesium, silicon and beryllium. The tensile strengths of these castings are as high as 61,200 psi., with 44,500 psi. yield strength (0.2%), and 16.5% elongation.



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Low Temperature Stress Relieving

While stress relieving has been widely used for years to reduce locked-up stresses in welded structures, its use has been limited largely to smaller sized objects that fit into conventional furnaces. However, a new method, called low temperature stress relieving, has been developed that can be applied to large welded structures in the field. During the last two years it has been used on ships, and on large tanks and pressure vessels.

A paper describing the principles and practices of this stress relieving method was presented by T. W. Greene before the International Acetylene Assn. convention in Detroit, May, 1948. The process consists of applying heat to the plate adjacent to the weld by means of a moving oxyacetylene blowpipe and then impinging a water spray on the plate approximately 6 in. behind the advancing heating flames. The temperature reached by the plate is around 350 F, as compared to 1100 to 1200 F usually required in conventional stress relieving procedures.

The object of the stress-relieving operation is to expand temporarily the plate on both sides of the weld differentially in relation to the weld. This is accomplished by heating as described above. The water spray rapidly cools the plate and causes it to contract behind the heated area. This cooling permits full reduction of residual weld stresses without overheating or upsetting the heated area, and without distortion, dimensional change or imposition of residual stresses elsewhere.

Does Lead Improve Machinability of Steels?

According to A. Schepers and R. Krauss in *Stahl und Eisen* (German), Feb. 16, 1948, previous investigations have not clarified two important questions concerning the merits of lead additions to free machining steels: (1) Will a lead addition alone impart free machining qualities to a mild steel? (2) How do leaded free machining steels compare with high sulfur steels? They conclude from their tests that the simple addition of lead does not make a low carbon, unalloyed steel a true free-machining steel. Likewise, the established, high sulfur, free-machining steels are superior to similar steels with lead. There is, therefore, no reason to adopt leaded steels, particularly in view of the danger of poisoning during the melting of such steels.

Various members of a Sub-committee on

Machinability Questions comment on these conclusions. They agree in general that the machinability of leaded carbon steels is not equal to that of high sulfur screw stock. It is possible, however, to improve the machinability of the high sulfur steels by the addition of lead. While the usual low carbon free-machining steels can be made satisfactorily with phosphorous and sulfur as free-machining additions, only lead comes into consideration for the alloy steels since it is the only one of the three that does not have a deleterious effect on the other properties. Even traces of lead (such as 0.03%) will have a noticeable effect on the machinability. In one case, the addition of lead to a manganese-vanadium steel caused an increased susceptibility to cracking in the heat treated condition.

The low lead content of the steels tested by Schepers and Krauss (0.07 and 0.14%) indicates that one of the problems with leaded steels is the introduction of suitable amounts of lead (about 0.25% is optimum). This difficulty is apparently one of the reasons why leaded steels are not being used in other countries to the extent that had been expected when they were first introduced. The Russians add lead as lead sulfide, but this causes an undesired increase in the sulfur content. Alloy steels, even with lead and sulfur, will probably not have as good machinability as the usual screw stock.

Milling Cutters by Precision Casting from High-Speed Steel Scrap

Milling cutters made from remelted high-speed steel scrap by precision casting have shown excellent performance in machining tests, according to a report by J. H. Penrose, Watervliet Arsenal, and available from the Office of Technical Services, Dept. of Commerce ("Precision Casting of High-Speed Steel Milling Cutters").

To make the cutters, a master pattern was machined in brass in accordance with dimensions for standard forged cutters, standard procedures being used to obtain the desired wax pattern. The patterns were mounted on wax-covered aluminum plugs. The mounted patterns were then precoated and invested according to standard arsenal practice. A large number of high-speed steel inserts used on large milling cutters were used in the experimental furnace charge. After the required baking out period the cutters were cast, cooled, broken out of the mold and sand blasted. They were then cut from the sprue by an abrasive cut-off wheel.

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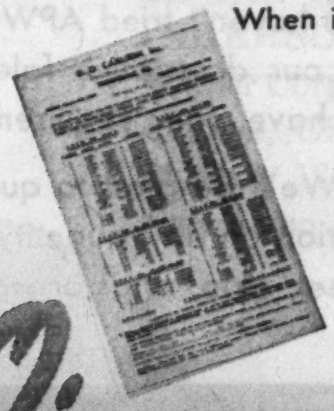

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DIGEST

steel is ordinarily broken up by hot work, an attempt was made to accomplish the same result by heat treatment. Following heat treatment, comparative tests were run with the precision cast and the forged stock cutters, which indicated that the precision cast cutters not only showed very good performance but were superior to the forged stock cutters.

Metals vs. Plastics

The organic plastics materials available to date are limited in their engineering applications when compared to metal, according to an article by R. G. Choller in the *ASTM Bulletin*, May, 1948. At the same time they have certain characteristics which make them attractive to both designer and engineer. The characteristics include low density, electrical properties, ease of fabrication, low thermal conductivity, high damping capacity, available transparency, and low unit cost for mass production items.

On the other hand, plastics are inferior to metals in strength, thermal expansion, modulus of elasticity, cold flow, heat resistance, water absorption, and hardness. They cannot be treated to effect localized change in properties so important to wear of moving parts. At the present time these latter properties are those which are required in most materials for engineering purposes and, consequently, metal will no doubt retain its position in the bulk of engineering applications for some time to come.

There is no doubt that the plastics industry will find far greater outlets for its products in those applications where plastic properties excel, with the possibility that with the extension of engineering knowledge for the proper application of these materials, new uses will be found as well. When this is accomplished, the author concludes that the proportion of plastics to metals should be much higher than it is today.

Electro-Zinc Phosphate Coatings for Iron and Steel

Electrolytically deposited zinc coatings are phosphatized mainly to minimize the formation of a white corrosion product and to improve the adhesion of applied organic coatings. Since it would be advantageous to carry out the phosphatization at the same

time as the deposition, this procedure was investigated and reported on by E. E. Halls in *Metallurgia* (English), May 1948.

The results of the direct electro-zinc phosphatization of iron and steel, it was found, are not the same as those obtained by phosphatizing electro-zinc deposits. The former procedure, therefore, cannot replace the latter in every case, but there are many instances where this can be done and some in which it is distinctly desirable.

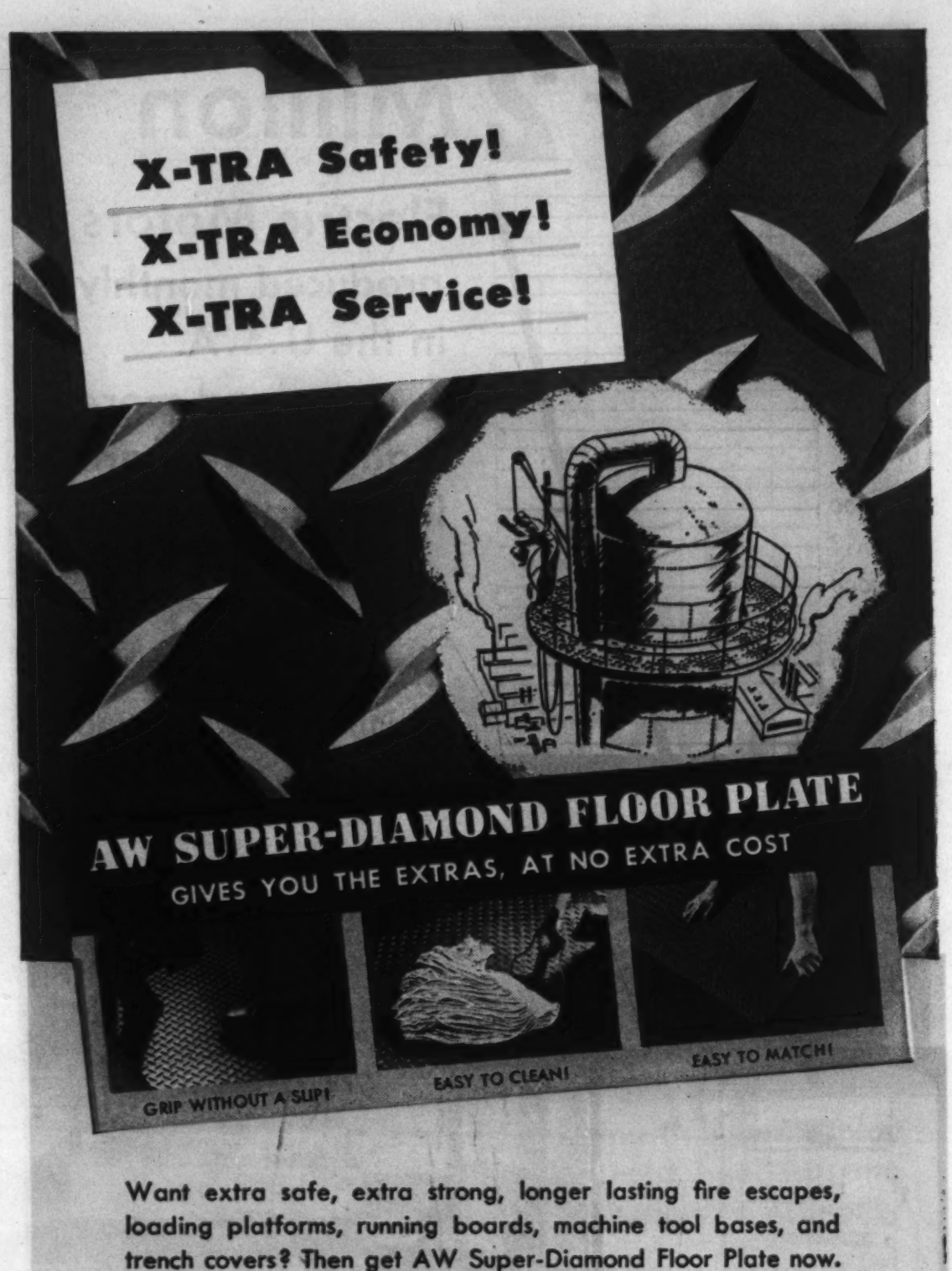
The direct electro-zinc phosphatization gives a dark grey coating, consisting of zinc phosphate intimately bonded to the base material. This coating gives a very good key for the adhesion of organic coatings of oil, lacquer or enamel and in itself has some rust resisting properties. The electro-phosphatized components do not have sufficient rust resistance, however, to be used without additional protection by an organic coating. The type of finishing media is a factor, as the performance of a cellulose enamel was markedly inferior to that of a stoved enamel.

The combined process of zinc deposition and phosphatization has much to recommend it. For work to be enamelled, it gives a better finish than that provided by phosphatization alone, and in some cases a better finish than that given by phosphatizing electro-zinc coatings. The speed and simplicity of the process should make it more generally adopted. For specific purposes, such as small screws and springs, it has the advantage of not causing any interference with dimensional fits.

Materials and Design for Light Weight High Strength Pressure Tanks

Advances in materials, design and fabrication of high pressure tanks for rocket power plants and torpedo air flasks was the subject of two important papers presented before the semi-annual meeting of the *American Society of Mechanical Engineers* early in June. Both papers were largely concerned with the complex problems arising from the requirement of light weight coupled with the requirement of high tensile strengths needed to withstand extremely high pressures.

C. C. Ross & R. B. Young in a paper on "The Design of Tanks for Liquid Propellant Rocket Power Plants" said that the materials phase of the rocket power plant tank problem is critical. Stringent weight requirements dictate the use of materials of high physical properties; and the equally stringent alignment and contour requirements limit the degree of heat treatment after assembly. The large physical size of



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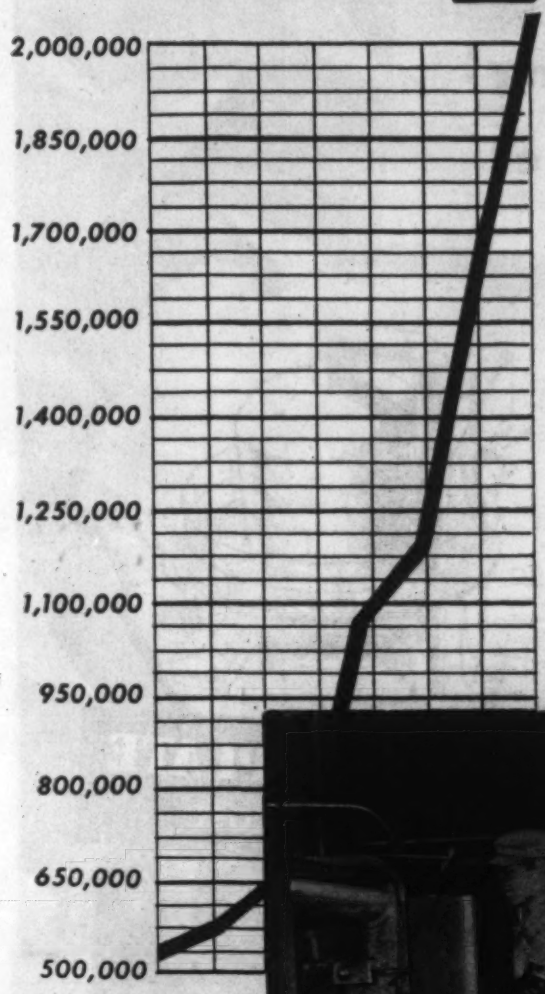

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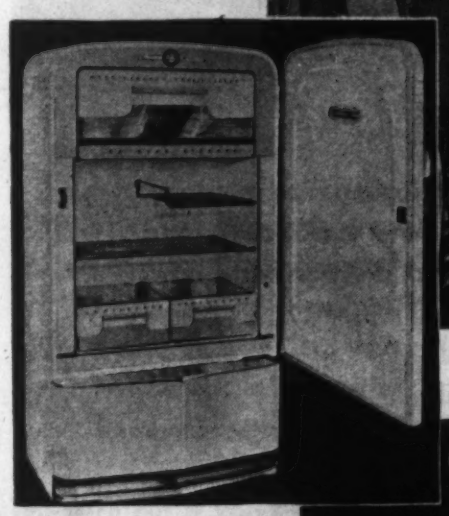

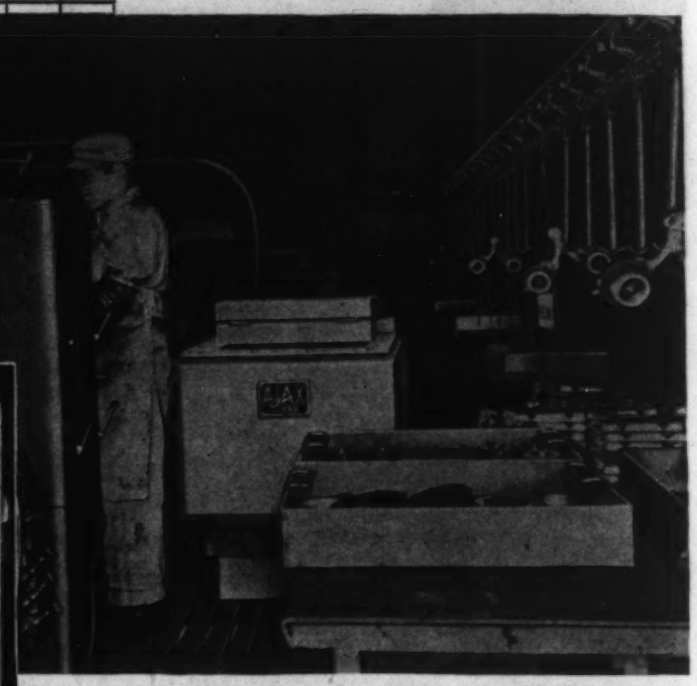

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the tanks also makes adequate and uniform heat treatment properties very difficult to obtain. Finally, due to the expendable nature of most rocket power plants and the possible need for large numbers, great emphasis must be placed upon the use, whenever possible, of non-critical materials.

The paper by J. J. Chyle & H. W. Brock on "Design and Fabrication of Welded Light Weight Pressure Vessels" dealt specifically with welded torpedo air flasks produced for the Navy during World War II. For pressure vessels where temperatures are normal, heat treated alloy steels can be used in the design to obtain low weight to stress ratio. Some of the most widely used alloys for this type of service are the low alloy steels. However, for pressure vessels like the torpedo air flasks, which must operate at elevated temperatures, a number of alloys were developed during the war that are available in sheet and plate form suitable for welding. Some of these alloys are modifications of austenitic stainless steels, the nickel-chromium alloys, and special heat resisting alloys.

The design of welded air flasks called for a nickel-chromium-molybdenum steel with vanadium. In order to successfully fabricate the flasks by welding, it was first necessary to develop procedures for welding of high strength, high alloy steel. This pioneering of high strength welding laid the groundwork for not only air flask application, but for welded landing gear and tank and propeller construction as well.

Plating on Magnesium

At about the time that successful plating on magnesium was announced in this country (see MATERIALS & METHODS, May, 1948), a paper was being presented in England before the *Third International Conference on Electrodeposition* describing some exploratory work on this subject.

In outlining the progress of their work, the authors, R. R. Rogers & M. L. Boyd, said that after unsatisfactory zinc deposits had been obtained in various fluoborate baths, a zinc sulfate—boric acid— ammonium fluoride—corn syrup—hydrofluoric acid bath was found which gave an adherent coating on AZ.31.X (3 aluminum, 1% zinc). Equally good deposits were obtained on the AZ.61.X alloy (6.5 aluminum, 1% zinc), but pure magnesium and the M.1 alloy (1.5% manganese) could not be plated satisfactorily with this solution.

An attempt to overcome the porosity in nickel deposits by the substitution of a

nickel-tin-nickel composite coating was unsuccessful. On the other hand, a zinc-copper-nickel composite coating that gave little or no porosity, except at the edges, was obtained on the AZ.31.X and the AZ.61.X alloys. Unfortunately, there was a tendency toward poor adhesion as the coating thickness increased.

Since it was difficult to obtain good nickel deposits on pure magnesium and the M.1 alloy, nickel and zinc plating tests were made on pure magnesium, M.1 and AZ.80.X (8.5 aluminum, 0.5% zinc) to which 0.1 and 1% lead or 0.1 and 1% silver had been added. A suitable plate could be deposited on the AZ.80.X alloy, with or without the lead or silver additions. None of the compositions based on pure magnesium was satisfactory. The presence of 1% silver or lead in the M.1 alloy made it easier to apply a deposit having a reasonably satisfactory appearance.

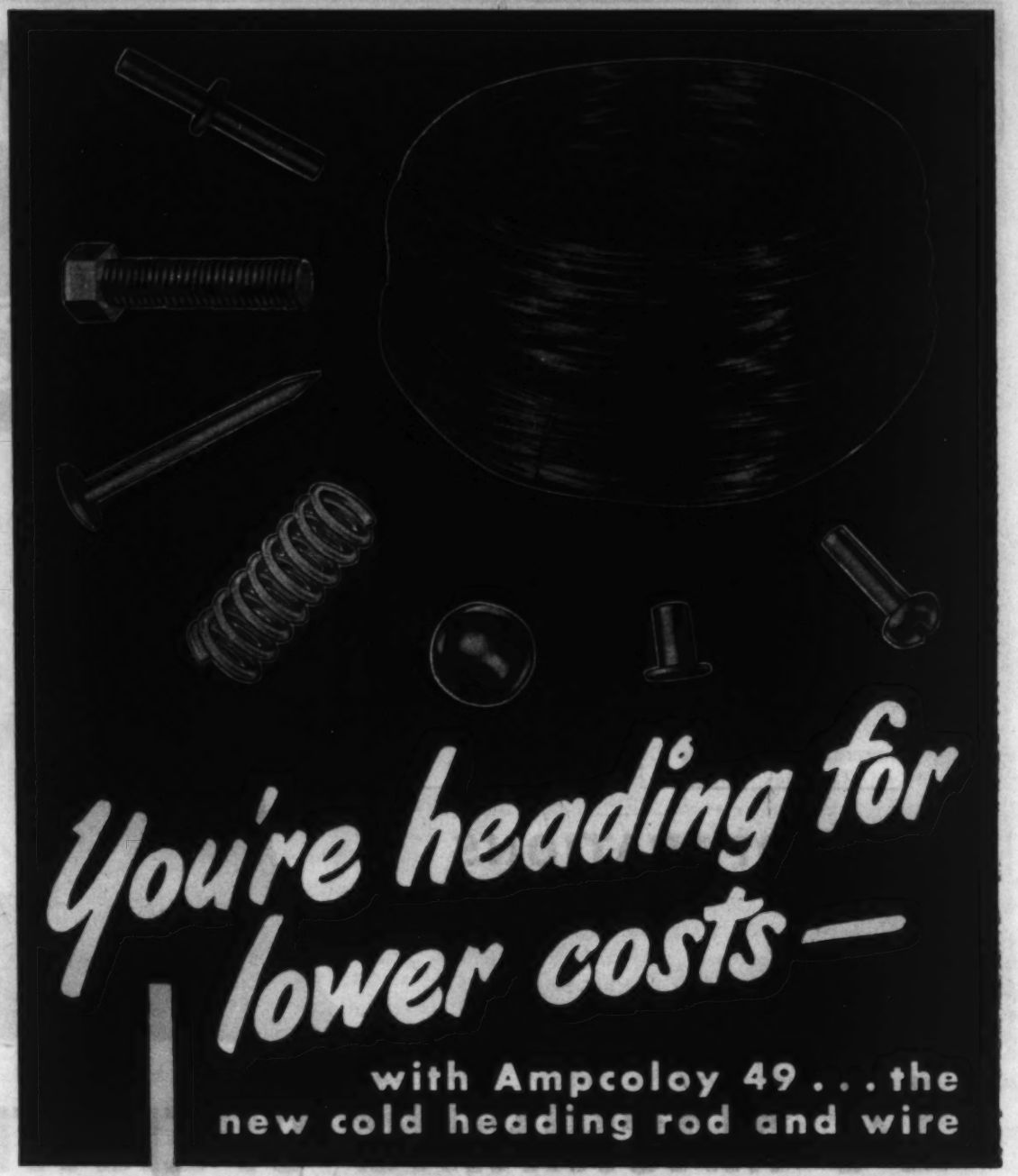
In the authors' opinion, the technique of electroplating metals on magnesium and its alloys has not advanced sufficiently to warrant its use on a large scale, except possibly in a few limited applications where the requirements are not particularly severe.

A New Synthetic Resin for Protective Coatings

A new synthetic lacquer for the protection of metals is reported by G. H. Ott in the Feb. 1948 issue of the French publication, *Métaux & Corrosion*. Although the composition of this lacquer, called Araldite 985, is not given, it is said to be a new type, differing from the phenol, urea and melamine base synthetics. It is furnished as a clear, neutral, concentrated, medium viscosity solution and is soluble in the usual types of solvents. The lacquer films are transparent, hard yet flexible, and can be hardened by heating for 20 to 160 min. at 320 to 430 F.

The color of the film varies from colorless to yellow brown, depending on the hardening treatment. If desired, it may be colored by means of organic dyes or the usual pigments. Despite the hardness of the film, the elasticity and adherence are excellent. Small containers can be formed directly from lacquered strip or sheet.

Numerous corrosion data are tabulated in the article to indicate the chemical resistance of the lacquer. In view of its possible utilization on aluminum containers to take the place of tin cans, its complete resistance to tomato puree is of particular interest. Sterilization had no effect on the film.



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Case History on METAL POWDER Savings

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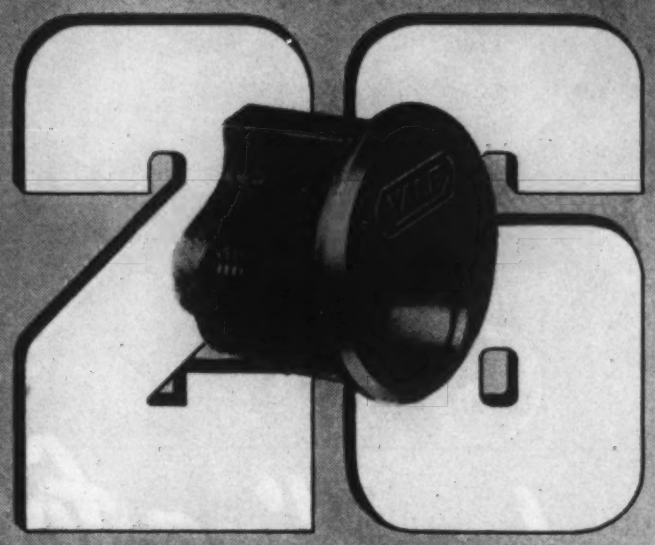

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2. Reduction in scrap loss—because of fewer machining operations;

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Iron and Steel

Stainless Steel in Chemical Processing. Complete data on the use of stainless steel in the pharmaceutical, dye, acids and other chemicals manufacture, general process and plastics industries, and soap making are presented by Allegheny-Ludlum Steel Corp. in an attractive, 36-page, illustrated catalog. Charts showing physical, fabrication and other data on the various recommended grades of stainless steel are included. (1)

Stainless Steel. Bulletin No. 112, eight pages, contains complete data on Durimet 20, a high strength, machinable, austenitic stainless steel recommended for use with about 125 corrosive solutions. Duriron Co., Inc. (2)

Clad Steels. The facilities of the Lukens Steel Co. for producing their wide range of clad steels, including Nickel-Clad, Stainless Clad, Inconel Clad and Monel Clad, are profusely illustrated and described in this 12-page bulletin. Typical applications of these clad steels are also presented. (3)

Acid Cleaner for Ferrous Metals. Complete data on the Oakite CrysCoat Process for precleaning, conditioning and rust-inhibiting ferrous metals prior to organic finishing, thus providing improved paint, are presented by Oakite Products, Inc. in their 6-page, illustrated folder. (4)

Carburizing Steel. Rycase, an improved, free-cutting, carbon-manganese carburizing steel especially adapted for case hardening, is discussed by Joseph T. Ryerson & Sons, Inc. in their 4-page, illustrated bulletin. Tables of chemical content, comparison of strength and recommended heat treatment are included. (5)

Nonferrous Metals

Silver Babbitt Metal. The numerous advantages of using Silver Babbitt No. 397, an alloy of silver with lead that is equivalent in physical properties to tin-base babbitts, are outlined in a new brochure and engineering brief issued by the National Bearing Div. of the American Brake Shoe Co. (6)

Cerium Metal. Engineering opportunities in the applications of cerium metal are discussed in a 4-page, illustrated article published by the General Cerium Co. (7)

Silver Brazing Alloys. How to join various tubing applications with Easy-Flo silver brazing alloys is clearly explained by Handy & Harman in their 4-page, illustrated bulletin, No. 38. (8)

Nickel Silver and Nickel Brass Alloys. A variety of nickel silver and nickel brass rods, extruded shapes, forgings and die castings produced by the Titan Metal Manufacturing Co. are described and illustrated in this 4-page bulletin. Analyses, physical properties and corrosion tests for six of these alloys are included. (9)

Foundry Alloys. Complete data on both V-5 and V-7 foundry alloys—chromium alloys balanced with manganese and silicon for easy and economical improvement of the qualities of gray cast iron—are presented by the Vanadium Corp. of America in their 6-page, illustrated folder. (10)

Parts and Forms

Continuous Cast Bronze Parts. The ability to procure mill lengths of Ampcoloy continuous cast rod and tubing for screw machine work is discussed by Ampco Metal, Inc. in a 4-page, pocket-size, illustrated bulletin, No. 92. (11)

Permanent Magnet Sub-Assemblies. Seven major advantages when using any one of a variety of permanent magnet sub-assemblies produced by the General Electric Co. are listed in this 4-page, illustrated bulletin, No. CDM-16. (12)

Cemented Carbide Products. Detailed specifications and prices of a complete line of cemented carbide products produced by Kennametal, Inc. are featured in this 70-page, illustrated catalog, No. 48. (13)

Mechanical Rubber Specialties. A complete line of molded, extruded, lathe cut and punched rubber products for use as components on many diversified types of manufactured and assembled articles is described and illustrated in this 44-page catalog, No. MS46, issued by the Lavelle Rubber Co. Detailed specifications are included. (14)

Bronze Bushing Bars. This handy, easily read wall chart lists the complete range of standard diameters available for immediate delivery and gives approximate weights of both centrifugally cast tubular bar stock and chill-cast solid round bars—furnished by the Shenango-Penn Mold Co. (15)

Metal Tubing. This 4-page, pocket-size booklet, issued by the Superior Tube Co., describes and illustrates ⅜-in. O.D. and under Weldrawn (welded and drawn) metal tubing that meets the most exacting requirements. (16)

Nickel Silver and Nickel Brass Alloys. A variety of nickel silver and nickel brass rods, extruded shapes, forgings and die castings produced by the Titan Metal Manufacturing Co. are described and illustrated in this 4-page bulletin. Analyses, physical properties and corrosion tests for six of these alloys are included. (17)

Plastics

Plastic Coatings. The use of various types of Amercoat plastic coatings for corrosion control in petroleum production and drilling is discussed by the Amercoat Div. of the American Pipe & Construction Co. in their 4-page, illustrated bulletin, No. PPB-48. (18)

Synthetic Fabrics. Typical applications, characteristics and technical data of two new synthetic fabrics—Fiberglas and Nylon Fabrics—are included in an 8-page, illustrated bulletin just released by Duplan Corp. (19)

Nonmetallics

Industrial Adhesives. The Fabrics Div. of E. I. du Pont de Nemours & Co. (Inc.) has released an 8-page, illustrated bulletin, No. A-6047, on Fairprene industrial adhesives for the priming, adhering, sealing, coating and impregnating of metal, plastics, wood, glass, natural and synthetic rubber, etc. (20)

Mechanical Rubber Specialties. A complete line of molded, extruded, lathe cut and punched rubber products for use as components on many diversified types of manu-

MANUFACTURERS' LITERATURE

factured and assembled articles is described and illustrated in this 44-page catalog, No. MS46, issued by the Lavelle Rubber Co. Detailed specifications are included. (21)

Methods and Equipment

Welding and Joining

Electrodes for Welding Alloy Castings. A compact, 2-page data sheet, No. 44822, on the 11 analyses of alloy electrodes for use in fabrication welding and salvage of both high and low alloy castings is available from Arcos Corp. (22)

Silver Brazing Alloys. How to join various tubing applications with Easy-Flo silver brazing alloys is clearly explained by Handy & Harman in their 4-page, illustrated bulletin, No. 38. (23)

Arc Welder and Power Unit. Complete specifications of the AC-AC rotary arc welder and power unit combination, which furnishes welding current and power to operate lights, tools and other electric motor driven appliances, are included in this 4-page, illustrated bulletin, No. 9507, released by the Hobart Brothers Co. (24)

Resistance Welding Control. Various types of control units for use with resistance welders are but a few of the electronics products featured in this 16-page, illustrated bulletin, No. DL-X-029, issued by the Raytheon Manufacturing Co. (25)

Forging and Forming

Wire Straightening Dies. Typical applications of tungsten carbide wire straightening dies are included in this 4-page, illustrated folder, just prepared by Adamas Carbide Corp. for producers of wire and wire straightening products. (26)

Contract Forming. The cold metal contour forming of difficult curved parts from carbon steel, aluminum, ductile bronze, stainless clad and magnesium strips, extrusions, bars, tubes and rolled or brake-formed sections is described by the Metal Form Div. of the Cyril Bath Co. in a 12-page, illustrated bulletin. (27)

Spring Looping Tool. This 2-page bulletin, No. HK-1, describes and illustrates the Hook-Kon spring looping tool, a new, easy-to-operate hand tool for looping the ends of coiled springs—produced by the Gardner Wire Co. (28)

Gang Punching Machines. Detailed specifications of a complete line of gang punching machines which increase the production of items requiring multiple punching of holes in steel sheets and plates are included in this 4-page, illustrated bulletin, No. GPM-48, offered by the Verson Allsteel Press Co. (29)

Notching Units. A complete line of notching units for use in notching mild steel sheets and angles up to ⅛-in. thick is described and illustrated in a 16-page bulletin, No. N, just released by Wales-Strippit Corp. Specifications and numerous diagrams are included. (30)

Machining

Milling Machines. The many new features of a variety of plain, universal and vertical dial-type milling machines are discussed by the Cincinnati Milling Machine Co. in their 16-page, illustrated bulletin, No. M-1623. General specifications and dimensional drawings are included. (31)

Self-Centering Turret. Basic facts, design features, operating instructions, specifications and prices of the Lign-O-Matic self-centering turret, which offers speed, accuracy and dependability in consecutive drilling operations, are contained in a 12-page, illustrated bulletin, No. 483, issued by Howe & Fant, Inc. (32)

Cemented Carbide Products. Detailed specifications and prices of a complete line of cemented carbide products produced by Kennametal, Inc. are featured in this 70-page, illustrated catalog, No. 48. (33)

Cutting Tools and Tips. A revised catalog, No. 48-T, incorporating the new standard identification numbers of their line of Talide tungsten carbide cutting tools and tips is announced by Metal Carbides Corp. (34)

Toolmakers and Engine Lathes. This 36-page bulletin, No. 1112, profusely illustrates and describes the Series 60 toolmakers and engine lathes available in 14-, 16-, 18- and 20-in. swings, each in a variety of lengths which are produced by the Monarch Machine Tool Co. Twenty pages are devoted to a review of 37 accessories built for these lathes. (35)

Automatic Chucking Machine. Two sizes of the Model 16 six-spindle work rotating type automatic chucking machine, produced by the New Britain-Gridley Machine Div. of the New Britain Machine Co. are described in this 8-page, illustrated bulletin, No. 742. Complete specifications are included. (36)

Metal Cutting Tools. A complete line of end mills, milling cutters, metal slitting saws, end mill holders, and other metal cutting tools is presented by Reltool Corp. in their new 72-page catalog. (37)

High-Speed Grinding Wheels. This 28-page catalog contains a price list on Royalite resin-bonded grinding wheels and vulcanite and corvite rubber-bonder wheels for use in steel mills, foundries and metal fabricating plants. United States Rubber Co. (38)

Machine Tools. The entire line of ram, saddle and electrocycle turret lathes, single and multiple spindle automatics, precision tapping and threading machines, and gear scroll chucks, all produced by the Warner & Swasey Co., is described and illustrated in a new 32-page catalog, No. 4803. Detailed specifications are included. (39)

Cleaning and Finishing

Plastic Coatings. The use of various types of Amercoat plastic coatings for corrosion control in petroleum production and drilling is discussed by the Amercoat Div. of the American Pipe & Construction Co. in their 4-page, illustrated bulletin, No. PPB-48. (40)

Felt Polishing Products. A complete line of Paramount Brand felt wheels, bobs, sheets, hair felt and marble buffers, produced by the Bacon Felt Co., is described and illustrated in a new 16-page brochure. Specifications and typical applications are included. (41)

Spray Nozzles. The use of Rotojet nonclogging spray nozzles for the application of rust-proofing, cleaning and rinsing solutions to metal surfaces is discussed by the Binks Manufacturing Co. in their 4-page, illustrated bulletin, No. 14. Specifications are included. (42)

Rust-Preventive Compounds. The Freedom-Valvoline Oil Co. has just released a 20-page booklet of general information on a variety of rust preventive compounds for ferrous and nonferrous finished metallic surfaces that can be applied by spray, brush, flush or dip at ordinary room temperatures. (43)

Plating and Processing Equipment. A complete line of automatic, semi-automatic and special machines for plating and other sequence processing is described and illustrated in a 36-page catalog, No. 148, just released by the Meaker Co. Specifications and practical plating pointers are included. (44)

Acid- and Alkali-Proof Tank Lining. Complete data on Nukemite 35, an acid- and alkali-proof tank lining that combines ease of application of a liquid coating with the immunity and long service life of good sheet membrane linings, are presented by Nukem Products Corp. in a 4-page bulletin. (45)

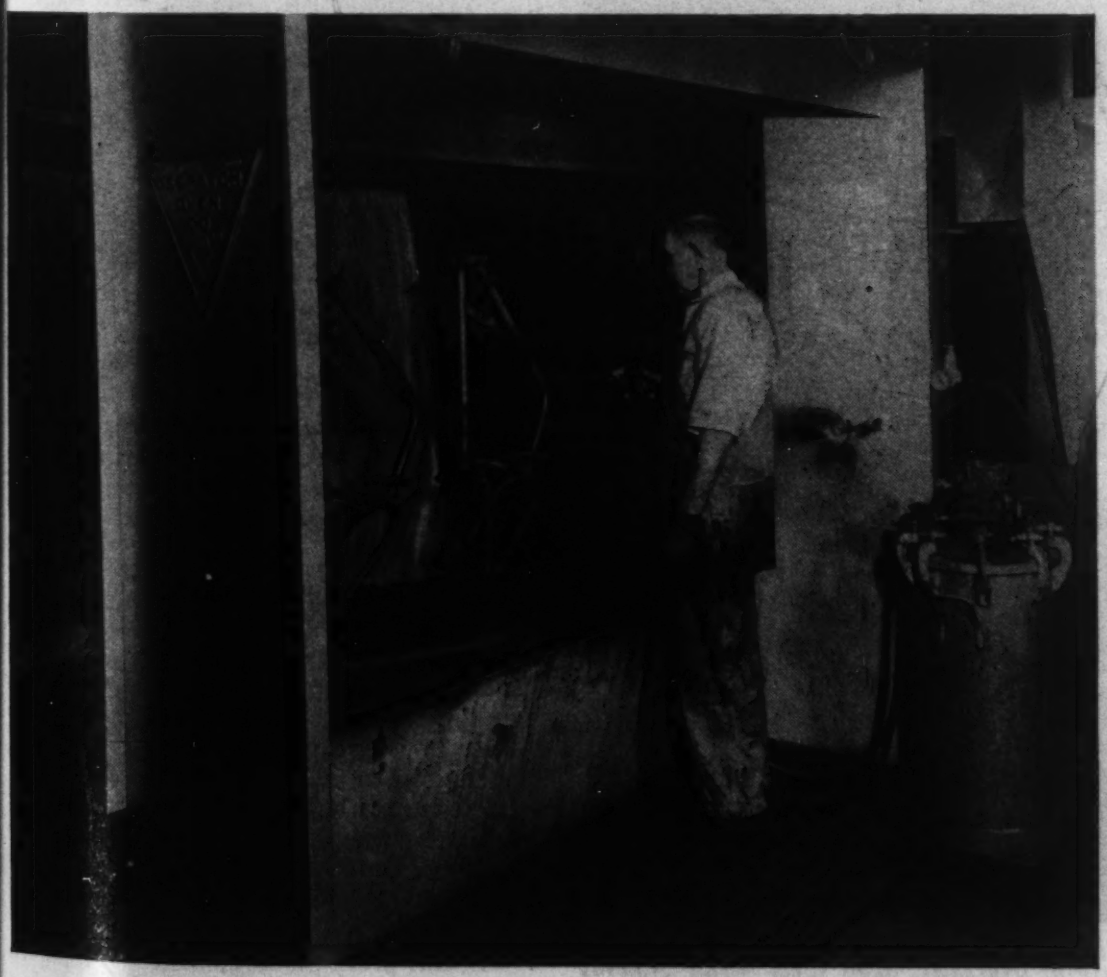
Acid Cleaner for Ferrous Metals. Complete data on the Oakite CrysCoat Process for precleaning, conditioning and rust-inhibiting ferrous metals prior to organic finishing,

New MATERIALS AND EQUIPMENT

Spray Booth Removes and Cleans Paint Laden Air

A water-wash spray booth for removing and cleaning paint laden air has been developed by *Despatch Oven Co.*, Minneapolis, Minn. The design provides at least five water curtains through which the air must travel before it is exhausted. The front curtain slopes only slightly to permit 56 gal. of water per min. to pass down each foot of the length of the curtain without splashing. The header supplying this flow and the two others inside the eliminator section are individually controlled so that the volume can be varied to meet demands. Axial flow fans provide a minimum of 150 cfm. per sq. ft. face velocity of air for removal of over spray.

Two headers running horizontally through the eliminator section have a series of orifices along the top. These orifices shoot the water against a sharp divider plate which forms two curtains of water. Baffles throw the water back across the air passage, creating another curtain. Then, moisture eliminating baffles remove excess moisture before air is exhausted. No paint builds up on the interior of the booth even after months of heavy operation. The settling tank of the booth collects the washed-out paint for reclaiming.



The new water wash spray booth in action. The water curtains can be seen in the rear.

Strain Tester for Rubber

A new device developed at the *National Bureau of Standards*, Washington 25, D. C., measures strain in vulcanized rubber, in contrast to the conventional tensile testers which determine tensile stress. In this apparatus the strain is measured at a definite time after application of a predetermined stress, while the usual testing method employs essentially the opposite procedure—that is, measurement of stress at a specified strain.

As many as 20 specimens for the strain test can be cut from a single test sheet, and it has now become possible to detect differences in the properties of rubber from different parts of the sheet, or to study the effect of aging on stiffness or modulus by means of a single test sheet.

The strain tester was designed to improve reproducibility of measurements and provide a high degree of accuracy in an apparatus suitable for routine testing. The tester is composed of two parts, built into a supporting table. One part, above the table, includes a mechanism for extending the specimen, an optical system for observing the upper bench mark on the specimen from a seated position, a mechanism for aligning a millimeter tape with the bench marks, a time cycle controller for regulating the sequence of operations, and a keyboard for selecting the load to be applied to the specimen. Beneath the table is the mechanism for applying the selected load. This mechanism employs eight solenoids for adding eight different weights singly or in combinations to a weight assembly attached to the specimen.

New Press Developments

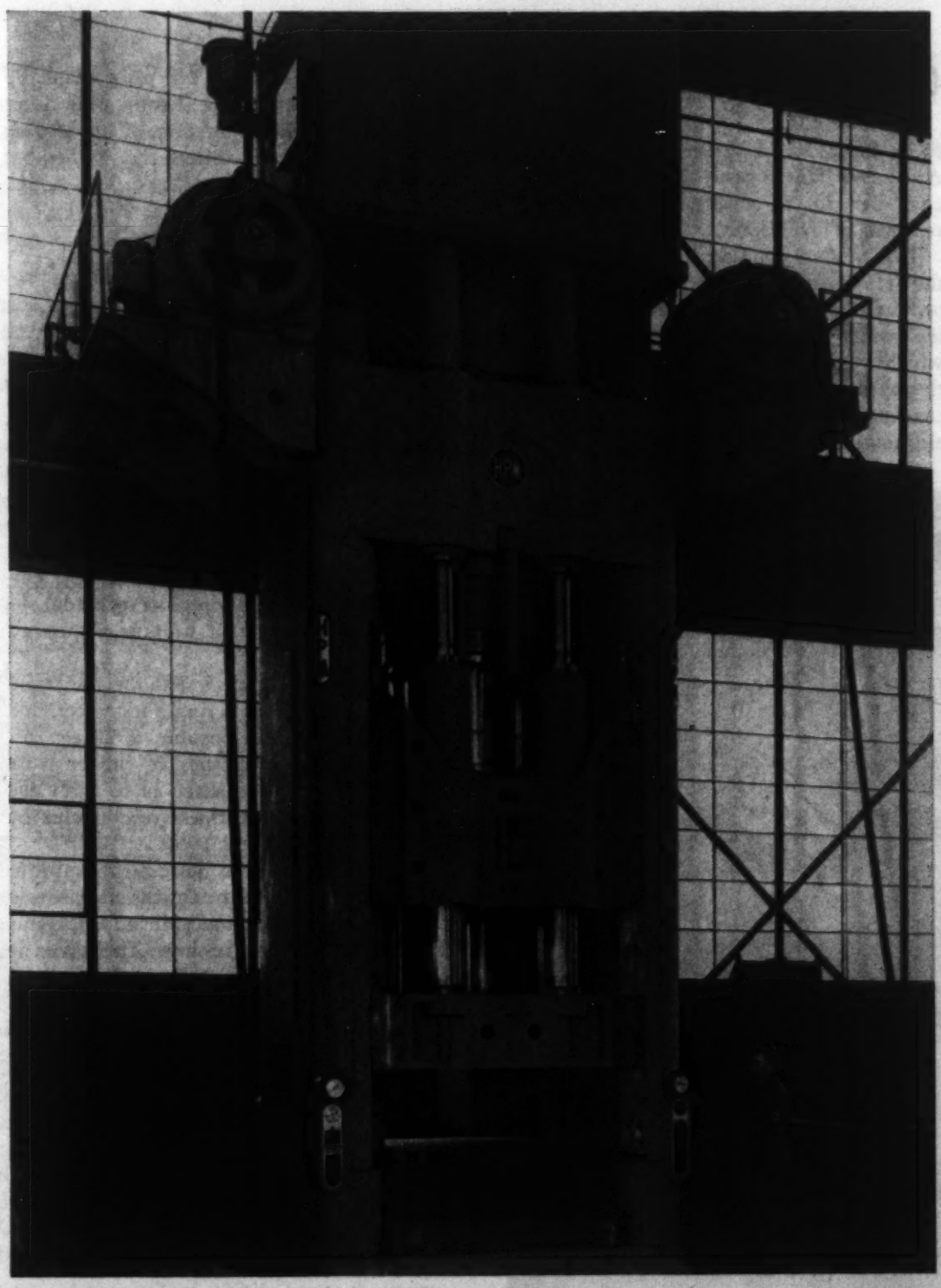
A variety of metal working presses have been announced recently. Some of these are brand new, while others are redesigns of older models. Altogether, they provide the engineer with a versatile group from which to choose.

Sheet Metal Drawing Press

The *Hydraulic Press Manufacturing Co.*, Mount Gilead, Ohio, has completed what is said to be one of the largest double action, all-hydraulic, deep sheet metal drawing presses ever built. It will be used to deep draw long cylindrical tanks for the storing of gas and liquids.

It weighs 78 tons and its overall height is 34½ ft. Pressing surfaces for mounting dies are 72 by 72 in. This press will draw sheet metal parts to a depth of 4 ft. A typical example of work scheduled for this press is a part 36 in. in dia. and 28 in. deep which will be drawn in a single stroke from a blank 72 in. in dia.

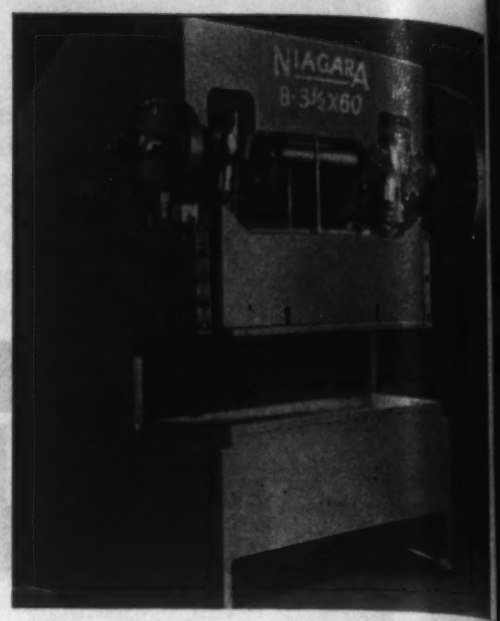
The press is equipped with 500-ton hydraulic blankholder. The stroke of the punch carrying slide is 72 in. Pressure of the punch carrying slide is also independently adjustable. Up to 1500 tons pressure can be applied by the punch. The press ram is equipped with a 600-ton internal high-speed booster ram. Pressing work up to 600 tons can be accomplished with the high-speed booster ram with automatic shiftover to higher pressures when needed. This feature is said to more than double initial drawing speeds. If drawing pressure above 600 tons is not required, press can be operated entirely on the 600-ton internal ram, thus obtaining a much faster drawing speed and consequently a faster operating cycle.



This huge press is one of the largest double action, hydraulic, deep sheet metal drawing presses ever built.

Double Crank Power Presses

A new line of welded steel gap frame double crank presses are being manufactured by the *Niagara Machine & Tool Works*, 637-697 Northland Ave., Buffalo, N. Y. The short strokes, rigid box crown and deep bed make suitable these presses for use with fine blanking dies and for forming work requiring heavy load at the bottom of stroke. Long or irregular sheets and strips can be fed either front to back or right to left as the bed is equally accessible. On geared presses, the back shaft does not cross the press, but is mounted in anti-friction bearings and entirely supported by the right hand upright. The pinion is supported between anti-friction bearings, thus holding the back shaft in perfect alignment with the main gear.



Welded all steel frame and slide is one of the features of this double crank press.

The presses are built in seven sizes ranging in capacity from 44 to 244 tons and the machines in each size are made in five to six widths to handle work requiring a wide range of capacity and bed area.

12-Ton Punch Press

A 12-ton punch press has been added to the line of presses produced by *Sales Service Machine Tool Co.*, 2363 University Ave., St. Paul, Minn. The press has a newly designed single stroke clutch together with an automatic brake. The clutch dog engages into a 4-point steel ring attached to the flywheel hub.

The clutch engaging and disengaging pawl is operated by a special built-in cam built in the crank drive integral collar of the crank. This cam revolves with the crank and when the clutch is tripped by a foot treadle, the disengaging pawl is locked in a positive position until the clutch dog is completely disengaged out of the clutch drive ring. The press also is equipped with a special cam actuated automatic brake.

Hand Punch Press

The *Leslie Welding Co.*, Dept. BC, 2943 Carroll Ave., Chicago, has redesigned their hand punch press, which has no ram, ways, or slides. Of all steel and welded construction, it is especially adapted to blanking operations on sheets of any type material. It is claimed that the large capacity of the press, together with the positive alignment feature, makes it practical for use in blanking operations which would ordinarily call for power press set-ups.

In this press, die alignment is maintained by the aligning leaf assembly, to one end of

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Since 1940, when Great Lakes Steel pioneered the application of high-tensile, low-alloy steel to cold-stamped automobile bumpers, there has been a growing trend to N-A-X HIGH-TENSILE STEEL in the automobile industry.

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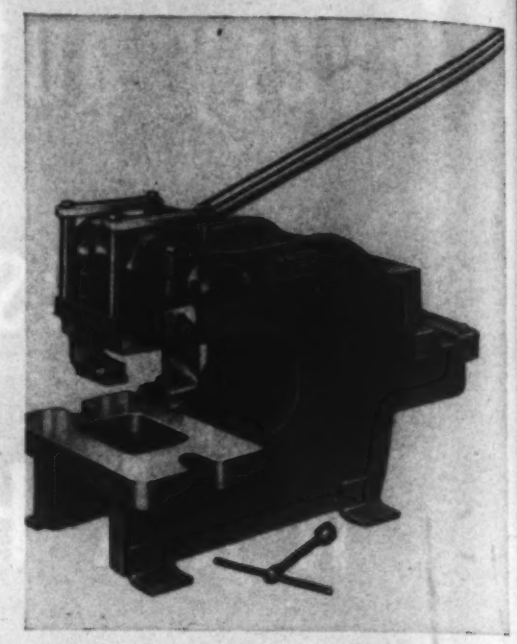
which the punch is fastened. The other end of the aligning leaf assembly is attached to press frame by means of a flat spring serving as a pivot when punch is raised and lowered. Because of the rigidity of the leaf assembly, except at its flexing point, and crankshaft construction that applied pressure to the leaf at two widely separated points, as in a double crank press, it is unnecessary to center the load on the punch plate.

The punch plate is 4 in., front to back, and 4⅜ in., right to left. The press has a throat depth of 6 in., a stroke of 7/16 in.



This hand punch press is suited to blanking operations on sheets of any type material.

with adjustment of ⅛ in. Die space, stroke down adjustment up, is 4¼ in.; hole in bed is 3⅛ in., front to back, and 4½ in., right to left. Press capacity is 3-in. dia. hole through 16-gage mild steel or 2-in. dia. hole through 12-gage mild steel.

High-Speed Press

Another redesigned press is the 4-ton Multipress model manufactured by *Denison Engineering Co.*, 1160 Dublin Rd., Columbus 16, Ohio. Three major design changes have been made: one in the control system, one in the operating component, and one in the power system. Speeds now possible are 1100 in. per min. approach speed, 450 in. per min. pressing speed and 750 in. per min. return speed. These new high speeds have been achieved without sacrificing either tonnage or operating characteristics of the standard models. This new press is said to be especially suited to high-speed applications.

Die Hobbing Press

The addition of a die hobbing press to its line of hydraulic presses has been announced by the *E. W. Bliss Co.*, 450 Amsterdam Ave., Detroit. Rated at 500 tons pressure at a pressing speed of 2 in. per min., the press is recommended for manufacturers needing a number of reproductions of certain dies for use in multiple stamping operations. These reproductions are obtained by forcing a master punch into metal blocks. The resulting cavities thus conform exactly to contours of the master punch.

This press is completely self-contained. The frame consists essentially of two steel

TUKON

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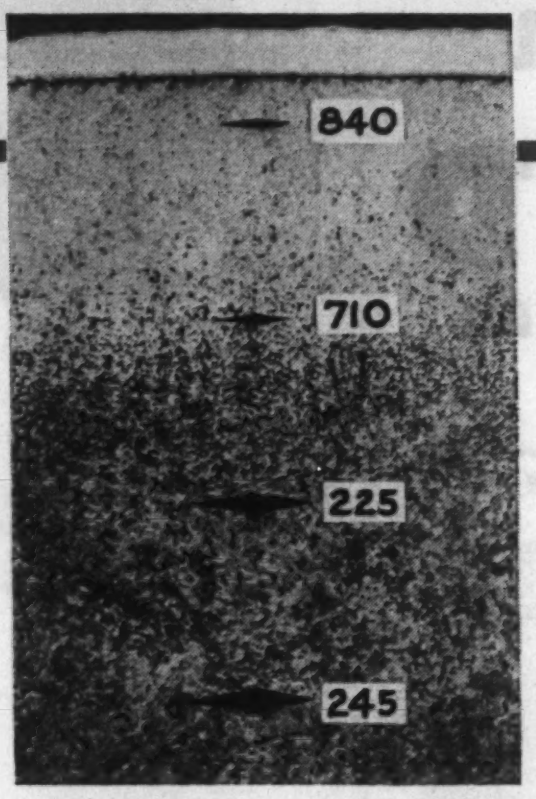

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TUKON TESTER *for* **KNOOP and 136° PYRAMID HARDNESS NUMBERS**

KNOOP hardness readings on induction hardened steel part. Indentations 0.010" apart. The TUKON Tester may also be used for testing thin material, small specimens, small diameter wire and for many kinds of research work. A new booklet contains a collection of up-to-date information about microhardness testing facts, written by actual users of TUKON Testers. Write for DH-7.

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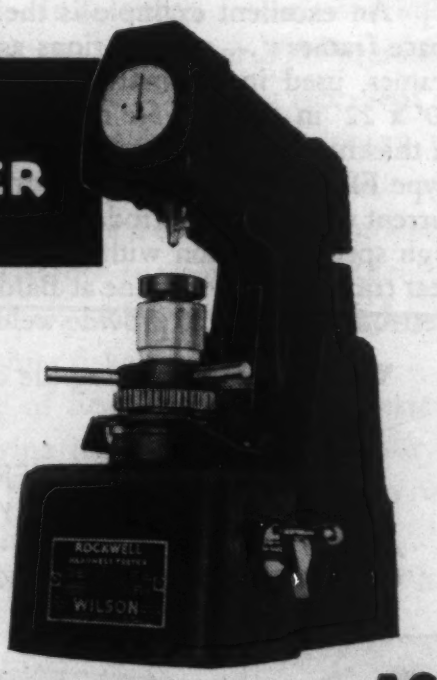

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For 27 years, WILSON has kept pace with—even anticipated—the needs of Industry in hardness-testing equipment. There has been constant improvement in existing instruments and development of new ones to meet more exacting requirements.

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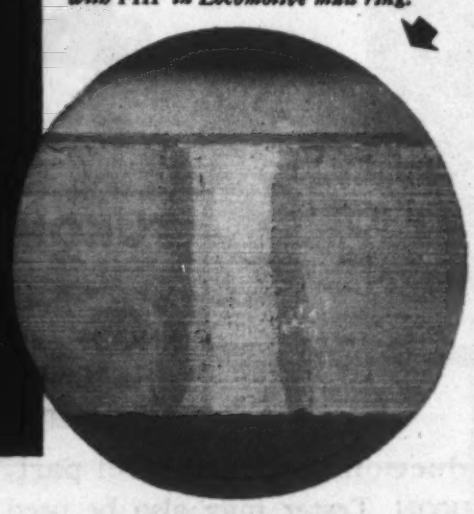
BALDWIN LOCOMOTIVE speeds PRODUCTION with FHP



Cross section of straight gap weld made with FHP in Locomotive mud ring.

Using the correct M & T electrode . . . plus a wealth of welding "know-how" is the combination that consistently produces high speed, high quality fabrications at low cost in the Eddystone plant of the Baldwin Locomotive Works.

An excellent example is their production line manufacture of water-space frames . . . or mud rings as they are more frequently termed. These frames, used in locomotive boiler assemblies range from 4′ x 5′ up to 10′ x 22′ in size and are made from bars 4″ to 8″ in width and 3″ to 5″ in thickness. All welding is done in straight-sided gaps with 5/16″ Murex Type FHP electrodes at approximately 600 amperes . . . an overloading of current which few electrodes will withstand. Results, however, are extremely high speed operation with no sacrifice whatever in welding quality . . . a neat trick but daily routine at Baldwin where welding ingenuity and M & T electrodes combine to provide welding speed, quality and economy.

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MUREX WELDING ELECTRODES
M&T ELECTRODES and GAS RODS
M&T WELDING ACCESSORIES

The new Bliss 500-ton hydraulic die hobbing press.

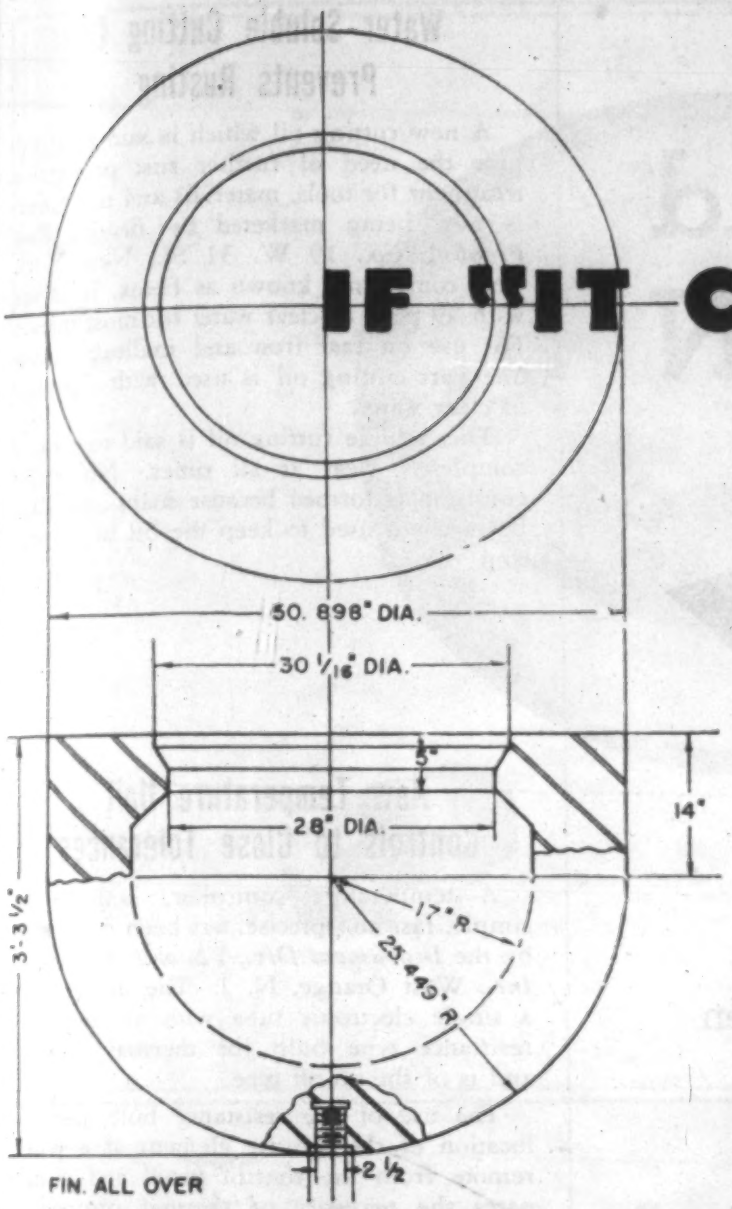
castings mounted on four heavy steel tie rods. Safety shields are provided for all openings to the die space. Control of the press is accomplished by means of manually operated valves fitted with handwheels. The stroke of slide is 6 in.; the vertical opening is a maximum of 10 in. and a minimum of 4 in.

● Expanded metal foils suitable for a great number of industrial uses are being produced by the *Research Products Corp.*, Madison, Wis. Expanded foils of aluminum and copper 0.003 in. thick are made by the company in a variety of patterns. The standard pattern has diamond-shaped openings approximately 3/16 in. wide and 9/16 in. long. The material is suitable for screening and electrical shielding when strength is not required, and it can be domed or formed into compound curvatures.

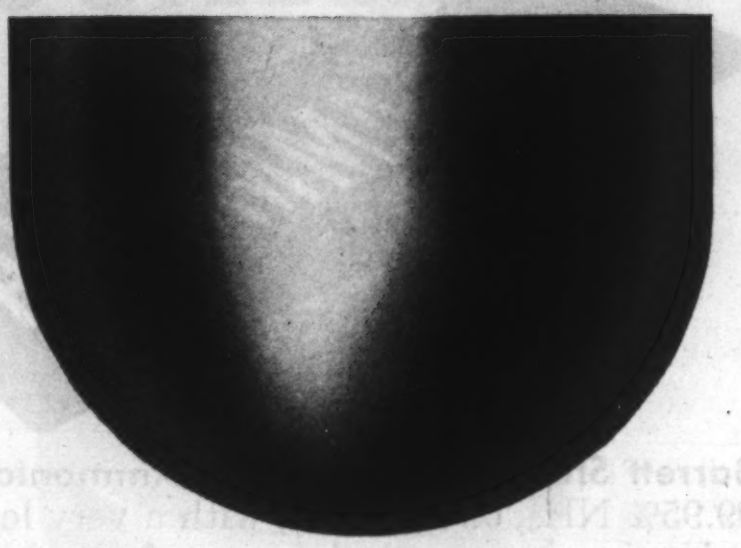
New Process Furnishes Bright-Annealed Cold-Rolled 18:8 Strip

Chromium-nickel 18:8 stainless steel is now available in bright-annealed cold-rolled strip form from the *Cold Metal Products Co.*, Youngstown, Ohio. A new process provides a bright finish without buffing or polishing. The bright finish is achieved by rolling with special tungsten carbide rolls and is retained during the annealed operation.

For the present, this new product is being offered in widths up to 7½ in. and in thicknesses 0.001 in. and heavier. It can be furnished in coils weighing up to 300 lb. per in. of width, and fractional-in. sizes can be bobbinwound to produce coils having many times the footage of coils wound in the customary manner.



IF "IT CAN'T BE DONE"



TRY MEEHANITE® DIES

THE MEEHANITE DIE shown is regularly performing a single pressing operation about which it had been said "it can't be done." Its function is to cold press 5/16" steel plate into half-ball shapes. These forms are welded together to produce gas storage vessels.

Used in conjunction with Meehanite drawing and clamp rings, the punch is 51" in diameter, 39½" long, and has a metal thickness of 8½". Its weight is about 13,000 lbs. In less than a year's operation the die has been used to produce about 1000 vessels or 2000 pressings.

Meehanite dies for drawing, forming and stamping represent one of the outstanding contributions from a production standpoint, offered by the controlled, dependable, better properties of Meehanite castings. Their engineering characteristics include better tensile properties, a high compressive strength, *real* resistance to wear, and heat-treatability —all a result of metallurgical controls which provide a tough pearlitic matrix evenly dispersed with graphite flakes.

In other fields including those of heat and abrasion resistance as well as in those general engineering jobs where better quality is required, Meehanite castings have frequently been the answer when it was thought that—"it can't be done."

For further details about Meehanite dies write for our bulletin entitled "Meehanite—an 'All-Around' Die Material."

MEEHANITE FOUNDRIES

American Brake Shoe Co.	Mahwah, New Jersey
The American Laundry Machinery Co.	Rochester, New York
Atlas Foundry Co.	Detroit, Michigan
Banner Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington, New Jersey
E. W. Bliss Co.	Hastings, Mich. and Toledo, O.
Builders Iron Foundry Inc.	Providence, R. I.
H. W. Butterworth & Sons Co.	Bethayres, Pennsylvania
Continental Gin Co.	Birmingham, Alabama
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co.	Portland, Oregon
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio
General Foundry & Manufacturing Co.	Flint, Michigan
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Kanawha Manufacturing Co.	Charleston, West Virginia
Koehring Co.	Milwaukee, Wisconsin
Lincoln Foundry Corp.	Los Angeles, California
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
Valley Iron Works, Inc.	St. Paul, Minnesota
Vulcan Foundry Co.	Oakland, California
Warren Foundry & Pipe Corporation	Phillipsburg, New Jersey
Washington Machinery & Supply Co.	Spokane, Washington
E. Long Ltd.	Orillia, Ontario
Otis-Fensom Elevator Co., Ltd.	Hamilton, Ontario

"This advertisement sponsored by foundries listed above."

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Barrett Standard Anhydrous Ammonia, 99.95% NH_3, oxygen free, with a very low dew point, is an economical source of pure hydrogen and nitrogen. When dissociated, each pound produces approximately 34 cubic feet of hydrogen and 11 cubic feet of nitrogen.

Engineers have discovered many advantages from the use of dissociated anhydrous ammonia in the production of controlled atmospheres in furnaces for bright annealing, clean hardening, copper brazing, sintering, reduction of metallic oxides, atomic hydrogen welding, radio tube sealing and other metal-treating practices. Anhydrous ammonia also has unsurpassed qualities in nitriding of steel, used as ammonia gas or dissociated.

Metallurgists are effecting real economies by using Barrett Standard Anhydrous Ammonia as a replacement for other more expensive sources of hydrogen and nitrogen. For information, contact Barrett, America's leading distributor of ammonia.

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40 RECTOR STREET, NEW YORK 6, N. Y.

Water-Soluble Cutting Oil Prevents Rusting

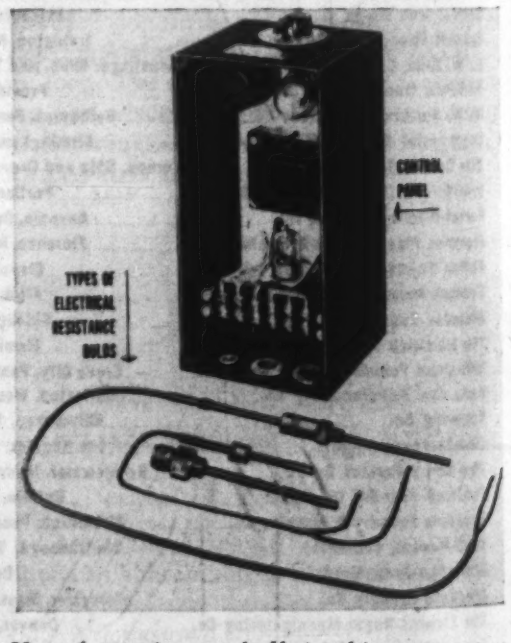
A new cutting oil which is said to eliminate the need of further rust prevention treatment for tools, materials and machinery is now being marketed by *Beacon Rust Proofing Co.*, 19 W. 31 St., New York. This compound, known as Ferox, is mixed with 49 parts of clear water for most metals. For use on cast iron and malleable iron, one part cutting oil is used with 33 parts of clear water.

This soluble cutting oil is said to remain completely clear at all times. No milky emulsion is formed because soaps and alkalies are not used to keep the oil in suspension.

New Temperature Unit Controls to Close Tolerances

A temperature controller, said to be simple, fast and precise, has been developed by the *Instrument Div., Thomas A. Edison, Inc.*, West Orange, N. J. The device uses a single electronic tube with an electrical resistance type bulb for thermal pick-up and is of the on-off type.

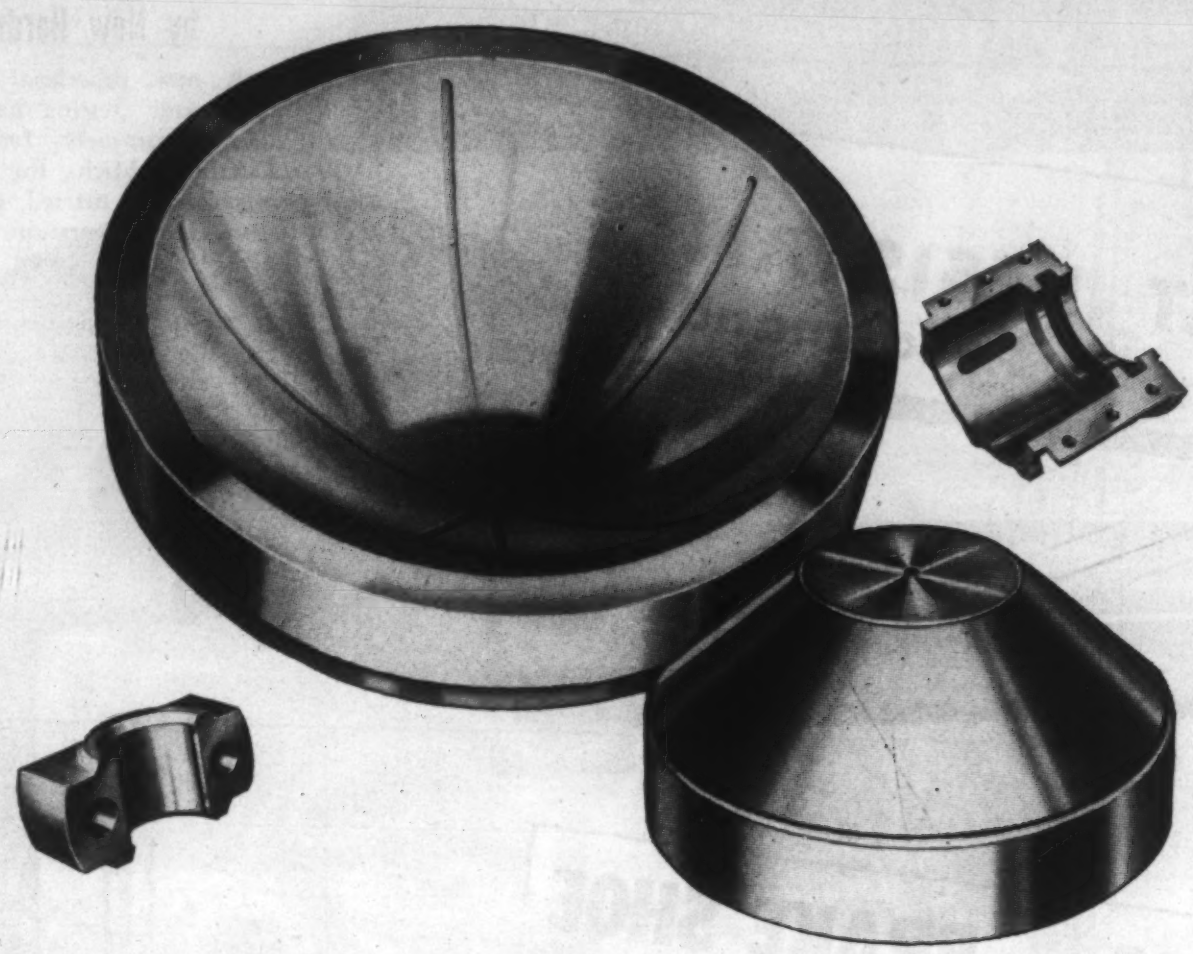
The use of the resistance bulb permits location of the sensing element at a point remote from the control panel and eliminates the necessity of thermal compensation. This device, which is non-indicating, may be used to control temperatures to close tolerances in solids, gases, or liquids. Units are available to cover the temperature



Use of a resistance bulb in this temperature controller permits location of sensing element away from control panel.

range from −100 F to 1200 F and are adjustable within a range of several hundred degrees.

Supply voltage may be 115 or 230 v., 50- to 60-cycle alternating current. Load capacity is 30 amp. at 115v., 20 amp. at 230 v. Accuracy of the controller is independent of usual voltage variation. Normal response time is under 3 sec., due to the patented bulb construction.



Large or Small—N-B-M Bearings are Better Bearings

You can get the benefit of National Bearing's research and engineering experience on any non-ferrous bearing application

The war against wear is universal — in a hydroelectric plant or a small lathe. Regardless of size, the best bearing is the bearing that is "N-B-M-engineered" for your own specific service conditions.

National Bearing Division — combined with American Brake Shoe Research offers you a unique service in the design and production of non-ferrous bearings. A service which covers every step in the process of solving your bearing problem—proper design, alloy, stress loading and lubrication.

In competitive selling every feature added to your product opens wider the door to a sale. When you plan to redesign bearings with an eye to longer and more trouble-free service, contact National Bearing Division for a fresh approach and the complete follow-through to the solution of your problem.

Whether the problem involves large bearings or small bearings—or non-ferrous castings of any description — use the specialized knowledge and engineering service of National Bearing Division.

NBM

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

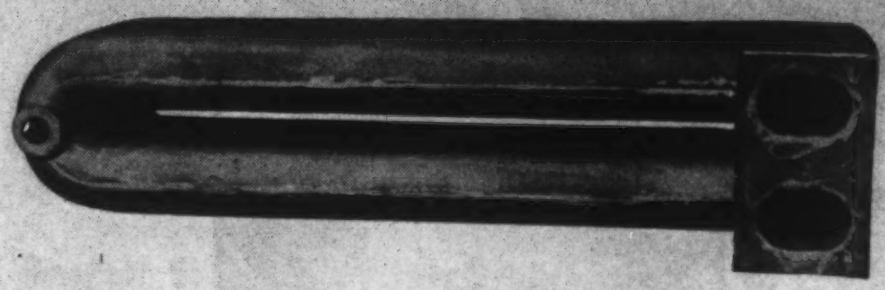
ST. LOUIS • NEW YORK

PLANTS IN: ST. LOUIS, MO. • MEADVILLE, PA. • NILES, OHIO • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

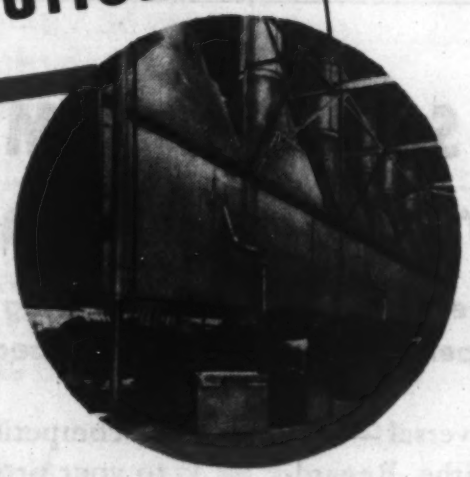
"Brake Shoe Research serves you today and anticipates tomorrow"

Wm. B. Given, Jr., President

when HEAT RESISTANCE is demanded...



CASTINGS BY BRAKE SHOE offer the solution



IN choosing a heating element for their tin plate immersion melting equipment, C. M. Kemp Mfg. Co., of Baltimore, Md., found the right answer in structurally sound non-porous castings made by American Brake Shoe Company. A heat-resisting grade of Meehanite® gave the necessary strength, pressure tightness and resistance to thermal shock.

In the casting itself, freedom from defects was made possible by Brake Shoe's experience-based foundry techniques and by its background of metallurgical knowledge and testing procedures. In the plant shown above, where a Kemp customer operates one of the world's longest lines of tin stacks, the production rate was increased, less flue gas consumed, temperatures were more closely controlled and dross formation cut down. We welcome inquiries on any phase of your need for castings, whether of ABK Metal (wear resist), Gray Iron or Meehanite® as made by Brake Shoe.

6361

Brake Shoe

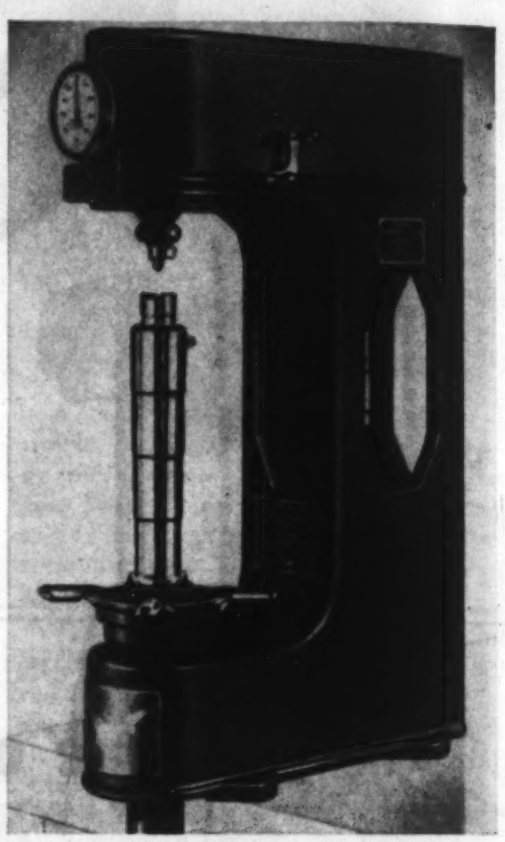
BRAKE SHOE AND CASTINGS DIVISION

230 PARK AVENUE, NEW YORK 17, N. Y.

Surfaces Are Not Marred by New Hardness Tester

A new superficial hardness tester for Rockwell" testing has been designed by *Clark Instrument, Inc.*, 10200 Ford Rd., Dearborn, Mich., for testing surfaces that must not be marred, even by the standard Rockwell indentation. Depth of penetration with this tester is held to limits of 0.005 in. or less.

The unit is particularly suitable for testing surface hardened steel, exceptionally thin metals, rolled sheet metal, or very small areas. The machine can also be used for standard Rockwell testing of metals that are of uniform hardness throughout, or wherever a test of surface hardness only is wanted.



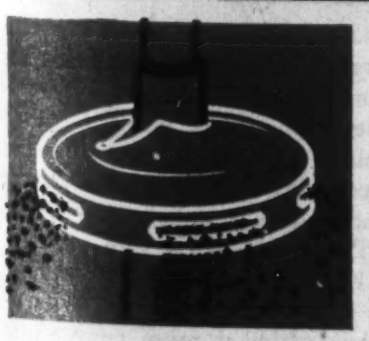
Depth of penetration of this superficial hardness tester is held to 0.005 in. or less.

The superficial hardness tester is available in three models, with 8-, 12- or 16-in. vertical capacity. Standard accessory equipment includes the following: (1) specially formed and lapped diamond cone penetrator; (2) 1/16-in. steel ball penetrator; (3) telescoping cover for elevating screw; (4) oil reservoir for elevating screw; (5) standard 3½-in. anvil; (6) checking anvil; (7) "V" anvil; (8) raised "V" anvil; (9) metal dust cover; (10) leatherette cover for instrument; and (11) test blocks.

● Recently developed by *Thermo Electric Co.*, Fair Lawn, N. J., is a new thermocouple connector panel providing a method for connecting any thermocouples of a group to any position on multiple recorders or indicating and controlling pyrometers. It is suited for pilot plant use or for checking temperatures in many industrial heat treating processes, aircraft engines, chemical processes, power plants and oil refineries.

NO METAL...

just hard-wearing, oil-resistant PERBUNAN



Resilient!—absorbs shock and strain without tearing—holds its shape under stress . . . all made possible by the tough one-piece, *no metal* construction of this BETTIS DUAL Pipe Wiper of *Perbunan* rubber. *Perbunan* was chosen for its ruggedness under heavy frictional wear and extremes of heat and cold *plus* its resistance to oils, tearing, and cutting.

New uses for *Perbunan* are constantly being discovered in all kinds of industries . . . for flexible parts in plant machinery . . . and for the finished product itself. *Perbunan's* long-wearing qualities and resistance to rubber-destroying fluids and temperature extremes have improved products and lowered maintenance costs in many cases.

Versatile Perbunan is readily adaptable to complex molds. It can be compounded in varying degrees of hardness and combined with other plastics to improve their properties. For further information on the applications and compounding possibilities of *Perbunan*, please write to:

PERBUNAN

REG. U.S. PAT. OFF.

The special rubber that resists oil, air, water, heat, cold and time

ENJAY COMPANY, INC.
Esso Building
15 W. 51st Street, New York 19, N. Y.

Fewer Wheels

With grinding wheels approaching 50% of the total cost to grind high speed tool steel, plant installed a Hoffman Flotation System, to serve 4 grinders.

Result: 88 grinding wheels saved yearly → $8960.00

Less Oil

Coolant saved by clarification in the Hoffman Flotation System amounted to 600 gallons in first year. → 216.00

More Production

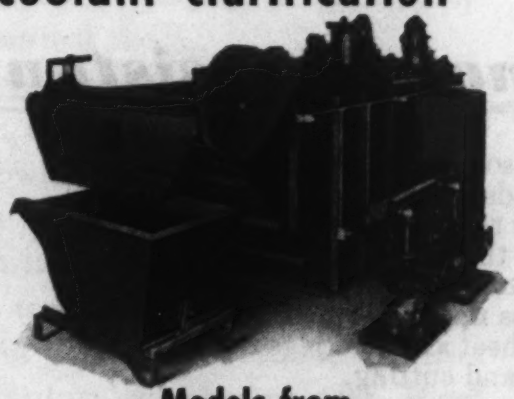
Operators no longer have sumps to clean—they stay on production. Saved on manhours for sump cleaning → 204.00

Total Savings for 1 year $9380.00

All yours with HOFFMAN FLOTATION EQUIPMENT

for *Automatic* coolant clarification

Convert "down" time into production time. And get savings on coolant, wheels and maintenance *more than enough* to pay back your investment. That, in very brief, is the story on the HOFFMAN Flotation System for coolant clarification. To get the complete details, write for bulletin A-690.



Models from 20 to 1,000 g. p. m.

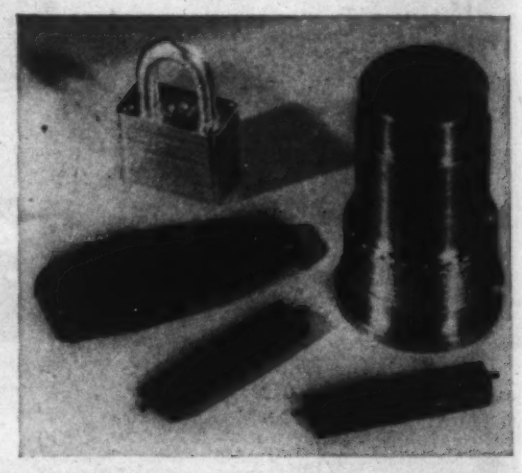
U. S. HOFFMAN MACHINERY CORPORATION
223 Lamson St., Syracuse, N.Y.
COOLANT FILTERS • FILTRATION ENGINEERING SERVICE

New Finishes and Coatings

Corrosion Preventives

A water-emulsion wax that is now being used as a rust-inhibiting coating for metals has been developed by *S. C. Johnson & Son, Inc.*, Racine, Wis. Applied by conventional dipping, spraying, wiping or flow-coating, this emulsion forms a dry wax plating on the metal part that checks corrosion. It is non-flammable and non-toxic, and gives high coverage of between 2500 and 3000 sq. ft. per gal. It can be removed by degreasing if desired. The coating can be used as a corrosion inhibitor on black-oxidized, phosphated and untreated metal surfaces, and also on painted and plated parts as a safeguard against scarring and chipping.

R. M. Hollingshead Corp., Camden, N. J., has available three types of rust preventive compounds. The solvent-base types afford longest protection. They are applied by cold dip methods. The films vary from medium-hard for severe outdoor exposure to the soft tacky film generally used on precision parts for indoor temporary storage. They are more difficult to remove than other types. A second type are the petrolatum grease compounds which are applied in the molten state. They solidify upon cooling and so parts can be handled much sooner than with solvent types. The thickness of coating can also be better controlled and is usually more uniform than the solvent type.



Metal parts protected from corrosion by the water-emulsion wax.

A third category are the oil types, which are suitable for protection of intricate assemblies or precision parts. They are easily applied, and, if necessary, easily removed.

Plastic Finishes

A new plastic which should prove useful in the decorative coating and film fields has been announced by *B. F. Goodrich Chemical Co.*, Cleveland. This material, called Geon Polyblend Latex, is a colloidal blend of Geon polyvinyl chloride and Hycar nitrile rubber. It is supplied as a liquid containing 45 to 50% solids, with a specific gravity of 1.08. The mechanical stability of the latex is reported good.

The material dries at room temperature to a tough, water-white film with excellent greaseproofing qualities. The film has a tear resistance of 1000 psi., a tensile strength of 2000 psi., and an elongation of 350%. A 10-min. fusion at 300 F. will raise the tensile strength to 3500 to 4000 psi. and the elongation to 600 to 700%, but will lower the tear strength by about 20%.

30 KW Drever Furnace for continuous bright annealing of stainless steel wire. Capacity 85 lbs./hr. (.020" wire); speed 50 to 200 feet per minute. 12 tube furnace with 9 foot heating chamber.

DREVER CONTINUOUS Bright Annealing Furnace FOR *Stainless Steel* AND *Alloy Wire*

Clean, bright wire, produced economically, to consistent high quality — those are the facts on this Drever Continuous Bright Annealing Furnace.

Incorporating complete automatic temperature control with either electric or gas firing, Drever Continuous Bright Annealing Furnaces have an effective operating temperature range from 1000° to 2100° F, and are available for wire sizes from the very finest up to .187" diameter. The furnace muffle tubes are made of seamless inconel, with sectionalized steel water jacketed cooling tubes.

Extreme versatility of production is made possible by the design of the pay-off and re-coiling mechanisms; each block is individually driven, or a group of blocks may be driven at the same speed. Thus, wire of different diameters may be annealed at varying speeds at the same time.

In addition to Stainless Steels, Drever Bright Annealing Furnaces are equally suited for bright annealing such metals as beryllium copper, nickel silver, silicon copper, brass, copper, optical wire, and many alloy steels. Proper atmosphere generation equipment is supplied depending upon the type of wire to be bright annealed.

If you are interested in further details on the performance of Drever Continuous Bright Annealing Furnaces for Wire, write us today.

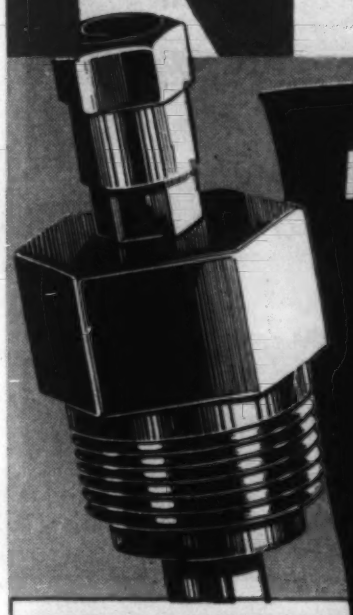
EXPERIENCE POINTS TO ➧ **DREVER CO.**

750 E. VENANGO ST., PHILA. 34, PENNA.

CONTINUOUS FURNACE LINES, HEAT TREATING FURNACES, DESCALING & ATMOSPHERE EQUIPMENT

NEW YORK & NEW ENGLAND—GERALD B. DUFF, 68 CLINTON AVE., NEWARK 5, N. J.
W. PENNA., W. N. Y. and OHIO—H. C. BOSTWICK, 3277 KENMORE RD., CLEVELAND 22, OHIO
IOWA, MINN. & WIS.—WALTER G. BARSTOW, 1302 FIFTH AVE. SOUTH MINN. 4, MINN.

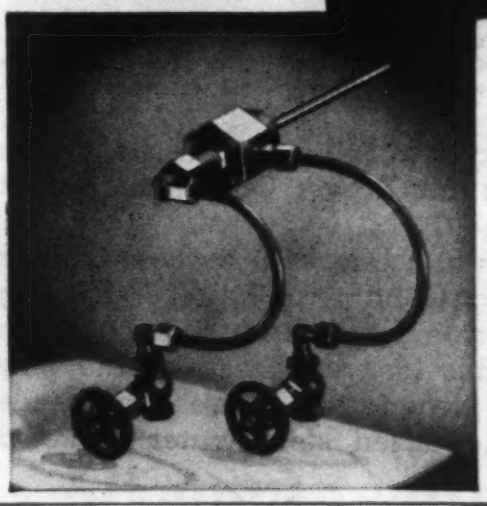
NOW



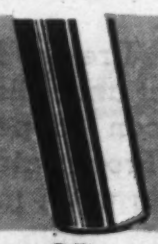
AVERT PLANT SHUTDOWNS! HAVE 2 FUELS AVAILABLE!

OIL STANDBY EQUIPMENT

—inserted in 'Surface' High and Low Pressure Types Gas Burners feature quick change-over—
GAS-TO-OIL and OIL-TO-GAS.



EASY TO INSTALL — change-over gas-to-oil and oil-to-gas is a matter of seconds for most installations.



PREVENTS LOST TIME

● Proved in 159 furnace installations —1100 burners, during winter of 1947 by 61 enthusiastic users. Provides low cost insurance against lost production and shipping schedule upsets. Builds employee relations and creates customer goodwill.

ACT QUICKLY!— the demand for this new Oil Standby Equipment is rapidly absorbing the available production facilities for installation this fall.

SURFACE COMBUSTION CORPORATION
TOLEDO 1, OHIO

'Surface' INDUSTRIAL BURNERS AND FURNACES

ATTACH THIS COUPON TO YOUR LETTERHEAD AND MAIL

☐ RUSH 8-page bulletin giving specifications and engineering details.
☐ Glad to have your engineer determine our requirements.

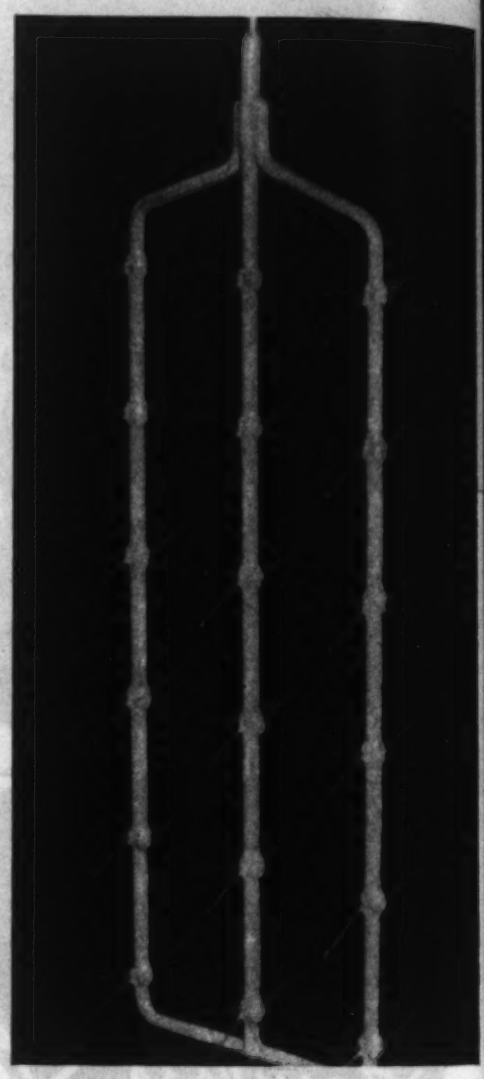
NAME.....

TITLE.....

RETURN THE COUPON ↑ Today!

The film will heat seal at 280 F. Its low temperature flexibility is good; it is still flexible at −50 F. It is tasteless and non-toxic. The very slight odor which is present in the cast film disappears upon fusion. A 2-mil film has a moisture vapor transmission of 6 to 8 gm. per 100 sq. in. in 24 hr. A dielectric strength of about 800 v. per mil open up the possibilities for the material in electrical applications.

Another new finish designed especially as a protective coating for aircraft surfaces has been placed on the market by *Regal Air Corp.*, 318 W. 39 St., New York. The finish is a clear solution that is sprayed



A plating rack coated with the plastic rack coating.

over metal and fabric to form a hard but flexible transparent film. It dries in 6 to 8 hr., and is said to protect the surface from abrasions, corrosion, weathering, stains and the like.

The development of a new liquid plastic plating rack coating has been announced by *Enthone, Inc.*, 442 Elm Street, Dept. MA, New Haven, Conn. This material is supplied as a viscous liquid containing 100% solids, which is applied by dipping to produce coatings varying in thickness from ⅛ in. to ¼ in. The material is applied over a primer coat and is baked at temperatures of 350 F. or higher for a short period of time.

The coating is stated to have high resistance to all types of inorganic solutions, particularly plating solutions and including chromium plating solutions. The surface produced is glossy so that solutions do not readily wet it. Racks coated with this material are being used in full automatic plating cycles involving the use of strong alkali cleaner, strong acids, acid or alkaline

Save

TIME AND MONEY WITH THIS NEW WHISTLER U-375

Adjustable Perforating Die Set

A MONEY-SAVING opportunity to prove in your own plant the many advantages of Whistler Adjustable Dies. Now being employed by thousands of metal working shops. The compact design of this special U-375 unit (10″ x 12″ working surface) provides up to 25 holes, 1/32″ to 3/8″ diameter. Pierce materials up to and including 1/16″ mild sheet steel... in one operation. Minimum centers of 7/8″ are permitted. Set-ups are made quickly and into production within hours. Precision perforating on long or short runs at much reduced expense. Re-use of punches and dies writes off first cost. The U-375 unit is shipped complete ready for immediate set-up.

Special Introductory Offer

To prove the advantages of Whistler Adjustable Dies under your production conditions, we are offering these U-375 units at a special low price.

- 1 DS-1012-1 (10″ x 12″) T Slotted Die Set
- 12 DR-375 Die Retainers
- 12 PR-375 Punch Retainers
- 12 PU-375 Round Punches
- 12 DBU-375 Die Bushings
- 12 S-375 Strippers
- 12 LLP-375 Locating Pilots
- 4 GA-375 Standard Gauges
- 1 SUP-375 Set-Up Plug

Punches and dies are your own selection of sizes from 1/32″ up to 3/8″ diameters. Everything needed to start production is included.

Shipped complete upon receipt of your order for only **$280**

Net F.O.B. Buffalo, N. Y.

SENT FREE ON REQUEST

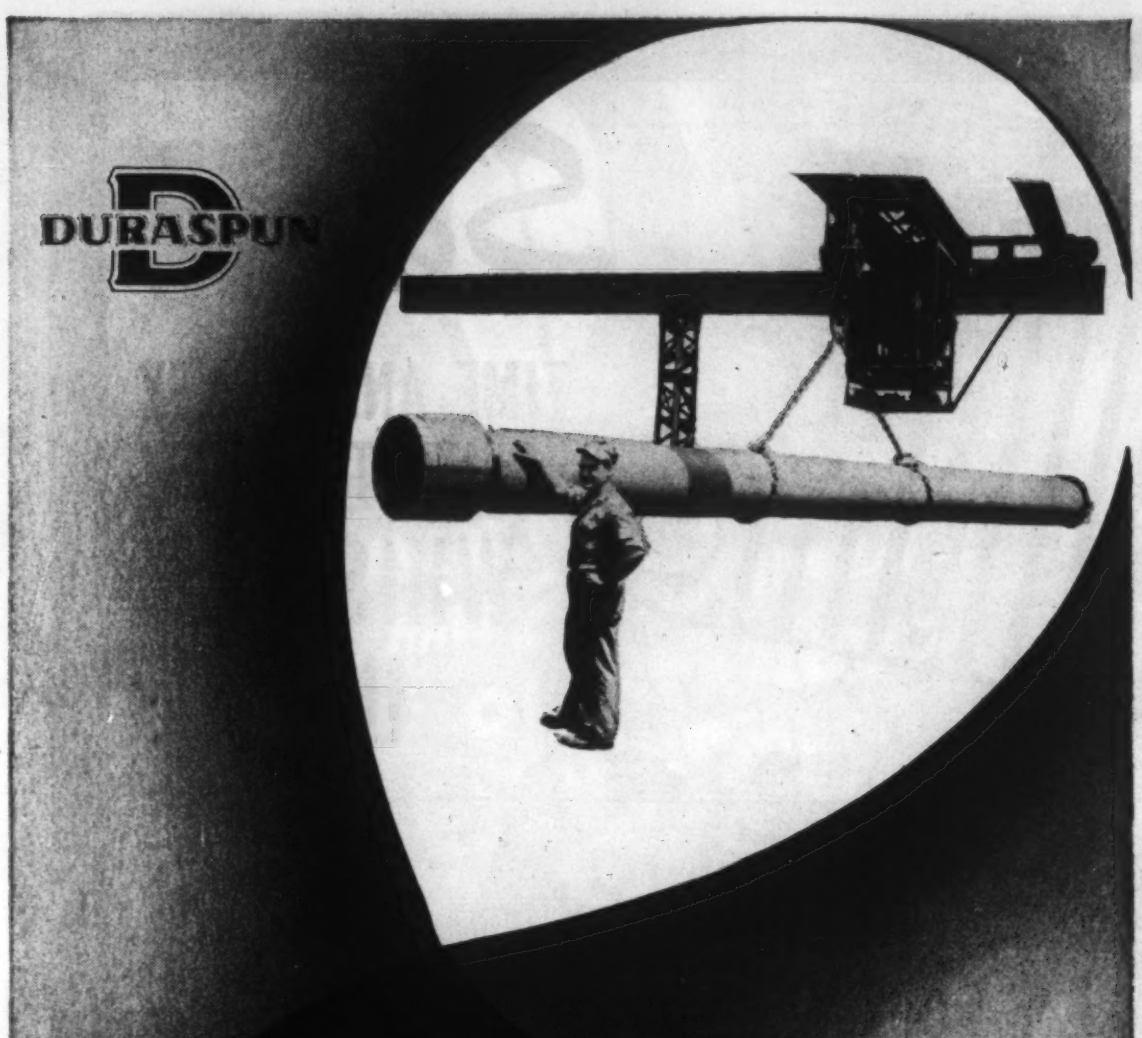
Special U-375 Booklet and General Catalogs.

In brief informative style, with clear-cut illustrations, this literature gives complete details about Whistler Adjustable Dies. Write today.

S. B. WHISTLER & SONS, Inc.

756 MILITARY ROAD BUFFALO 17, NEW YORK

See us at Booth 1502 National Metal Exposition October 25 to 29—Convention Hall—Philadelphia



23 FEET of a 19 INCH *Centrifugally* CAST "CARTRIDGE"

It's alloyed to meet a highly corrosive condition. It's centrifugally cast to give it the higher strength and greater metal density to meet a tough structural requirement. It's typical of what we can do in our centrifugal casting department. In this case two sections were made and welded together.

May we suggest that if you have need for any high alloy pipe or tube ranging in diameter from 2½ inches to 24 inches and, depending on diameter, up to 15 feet in length, you look into our centrifugal casting service.

THE DURALOY COMPANY

Office and Plant Scottdale, Pa. • Eastern Office 12 East 41st Street, New York 17, N. Y.

Los Angeles & San Francisco KILSBY & HARMON

Detroit E. B. CORNELL & ASSOCIATES

METAL GOODS CORP. St. Louis • Houston • Dallas • Tulsa • New Orleans • Kansas City

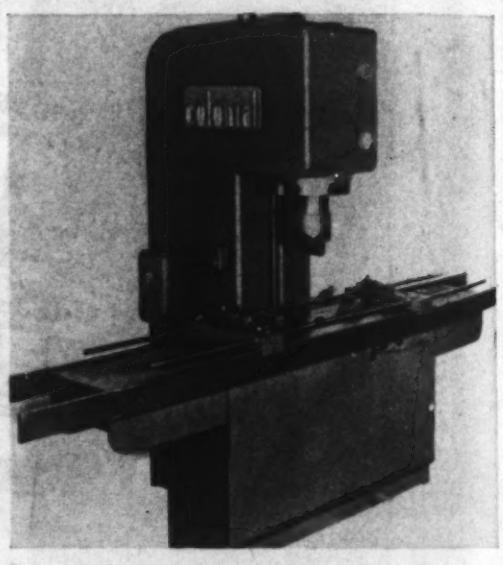
8-DU-3

plating solutions, and chromium plating solutions. Repair of the coatings for replacement of hooks is done by the use of a patching cement and a radiant energy heat lamp.

Straightening Press Designed for Finished and Rough Work

A new 75-ton model has been added to the line of hydraulic straightening presses manufactured by *Colonial Broach Co.*, P. O. Box 57, Harper Station, Detroit. Designed for handling both finished and rough work, the new press employs a double rail straightening fixture to take care of the larger and heavier work for which this high capacity press is designed.

Reinforced welded steel construction is used for the open side frame design. Motors are built-in. Rams are direct acting from high capacity hydraulic cylinders mounted in the head, and are available with bronze ram noses in place of the standard steel design, if desired. The same



This 75-ton straightening press can be used for handling both finished and rough work.

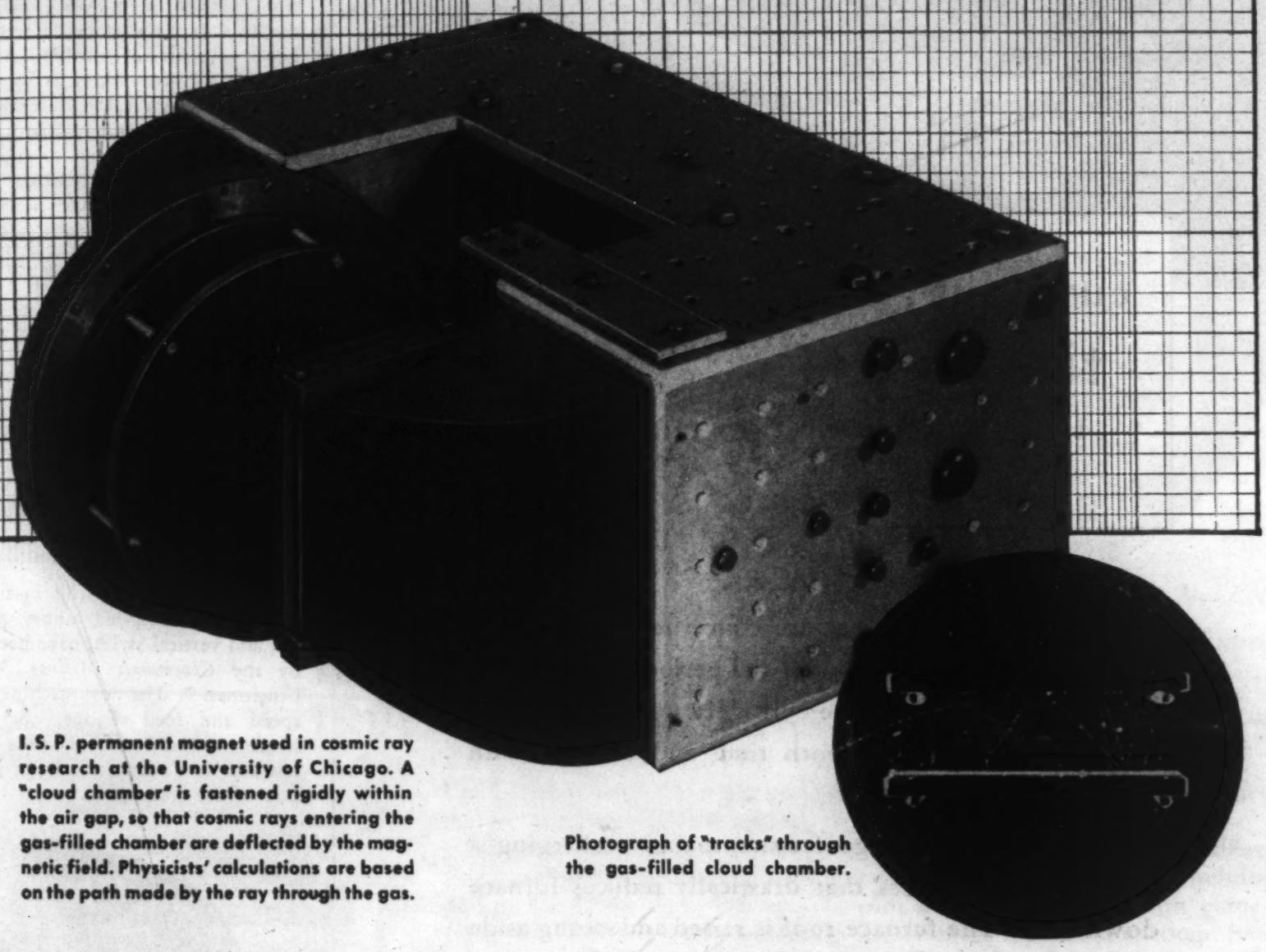
is true of work support anvils. Work supports may be either center or roller type, depending on the nature of the work to be handled. Guide rails are extra long to prevent sagging of long work beyond the work anvils. Standard equipment includes hand controls and pressure gage.

Floor space is 54 by 140 in., including the straightening fixture. Stroke of the ram is 12 in., with a power stroke speed of 45 in. per min. and a return speed of twice this amount. The hydraulic system is operated through a 15-hp., 1800-rpm. motor.

● Users of the submerged-arc welding process can now obtain a newly developed bronze bare wire in coils that is satisfactory for overlaying large steel areas for bearing, wear- and corrosion-resistant service or for joining aluminum bronze. The new wire, called Ampco-Torde 10 Bare Wire, is produced by *Ampco Metal, Inc.*, Milwaukee 4, Wis. It is supplied in coils in ⅛- and 3/16-in. dia. sizes.

Permanent Magnets do it Better in ...

Scientific Research



I. S. P. permanent magnet used in cosmic ray research at the University of Chicago. A "cloud chamber" is fastened rigidly within the air gap, so that cosmic rays entering the gas-filled chamber are deflected by the magnetic field. Physicists' calculations are based on the path made by the ray through the gas.

Photograph of "tracks" through the gas-filled cloud chamber.

In Cosmic Ray research at the University of Chicago, an I. S. P. permanent magnet helps speed the study of particles unbelievably small —yet with energy that staggers the imagination. U. of C. physicists asked our engineers to furnish this special permanent magnet—*with a 6.5 inch air gap*—to make their studies possible at high altitudes.

WORLD'S LARGEST

The resulting magnet—of Alnico V—is the most powerful permanent magnet in history. Yet its weight is only a *fraction* of that of an electromagnet with comparable strength; and it requires no electric current for operation. Thus it can be taken to mountain peaks or up in airplanes for work in rarefied atmospheres. And it has these additional advantages: no heat produced, no shock hazards, *no operating costs.*

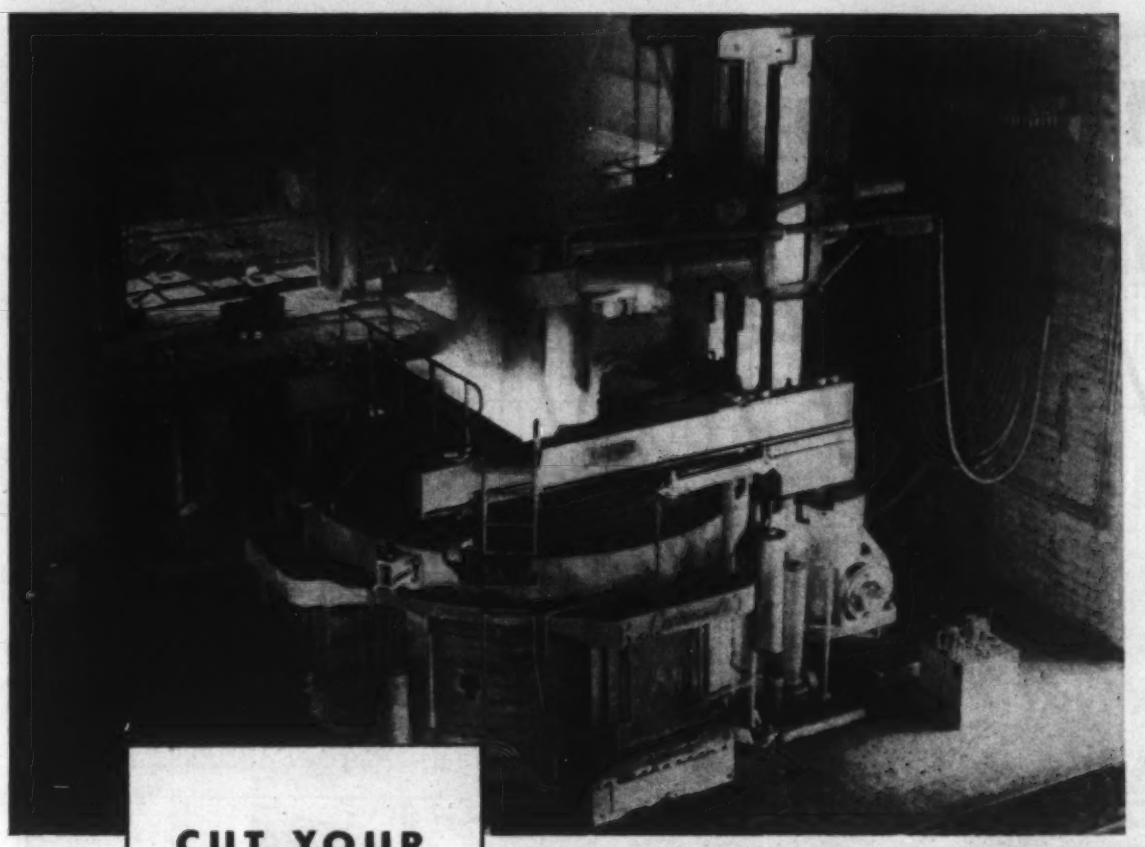
"PACKAGED ENERGY" MAY BE YOUR ANSWER

Permanent magnets, with their "independent power," may be the solution to *your* problems —in new equipment designs—or in obtaining higher efficiency, more economy in present products. Investigate *now.* Sizes and materials for a complete range of uses. Write today, Dept. D-8.

THE INDIANA STEEL PRODUCTS COMPANY

PRODUCERS OF "PACKAGED ENERGY"
6 NORTH MICHIGAN AVENUE · CHICAGO 2, ILL.
SPECIALISTS IN PERMANENT MAGNETS SINCE 1910

PLANTS { VALPARAISO, INDIANA / CHAUNCEY, NEW YORK



CUT YOUR **time** LOSS

with top-charging

MOORE RAPID *Lectromelt* FURNACES

As far as cost and out-put are concerned, non-productive time is waste time—and the periods consumed in recharging a furnace are certainly non-productive. That's why you save—both time and money—with Lectromelt furnaces.

Lectromelt's top charge feature makes recharging a quick, simple process that drastically reduces furnace down time. The furnace roof is raised and swung aside hydraulically, the charge is dropped in and the roof repositioned. Then you're ready for "power on".

Lectromelt furnaces are available in sizes ranging from 100 tons to 250 pounds. Write today for complete details.

MANUFACTURED IN

CANADA	Lectromelt Furnaces of Canada, Ltd., Toronto 2
ENGLAND, SWEDEN, AUSTRALIA	Birlec, Ltd., Birmingham, England
FRANCE	Stein et Roubaix, Paris
BELGIUM	S. A. Belge Stein et Roubaix, Bressoux-Liege
SPAIN	General Electrica Espanola, Bilbao
ITALY	Forni Stein, Genoa

PITTSBURGH LECTROMELT FURNACE CORPORATION

Pittsburgh . . 30, . . Penna.

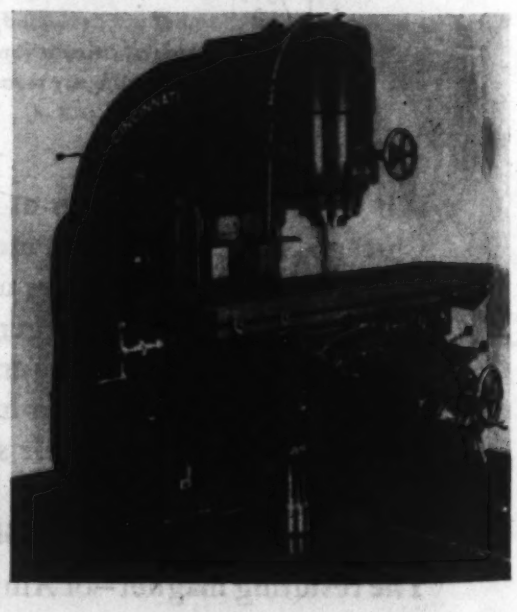
Abrasive Cutting Machine Is Completely Automatic

A fully automatic abrasive cutting machine with an oscillating head is now available from the *Andrew C. Campbell Div., American Chain & Cable Co., Inc.*, Bridgeport 2, Conn. This new machine is sequence timed and, therefore, regardless of size of stock being cut or length of feed, no adjustment of the timing cycle is required. It will cut materials up to 6-in. dia. solid stock.

The machine is completely automatic. Here is the cycle of operation: Abrasive wheel cuts through work. During this time the feed carriage is being returned to left hand, or starting position. At completion of cut, abrasive wheel is raised to "UP" position. Work clamps are raised clear of work and at the same time clamp of feed carriage is then moved to right against its stop. Bar clamp is released and simultaneously the work clamp moves downward and securely clamps bar into V-block. Abrasive wheel is started downward and cycle repeated. This fully automatic machine is said to cut larger diameters faster than ever before possible by the automatic abrasive method.

Speed and Feed Changed Automatically in New Milling Machines

New dial-type milling machines in medium and high-speed ranges, plain, universal, and vertical styles, have been announced by the *Cincinnati Milling Machine Co.*, Cincinnati 9. The new machines have power speed and feed change, operable with a single two position lever at the front control position or a similar lever at the left-hand side of the column.



Here shown is the vertical model of the new dial type milling machines.

The machine performs the actual work of shifting gears. While the operator holds the lever in the speed or feed change position, the speed or feed dial, as the case may be, clicks around, and upon release of the lever, the proper gears are in mesh for the speed and feed indicated. This feature is desirable where rough and finish cuts, or a

HERE'S HOW...

TO PLAN YOUR TOOLROOM HEAT TREATING DEPARTMENT

Published to assist those planning new or expanded heat treating departments. It's yours for the asking.

Material contained in this 24 page booklet, prepared by the Lindberg Engineering Company, is based upon years of experience in helping design hundreds of toolrooms . . . plus additional information gained from the 24-hour-a-day operating experiences of the toolroom heat treating department of the Lindberg Steel Treating Company, the world's largest.

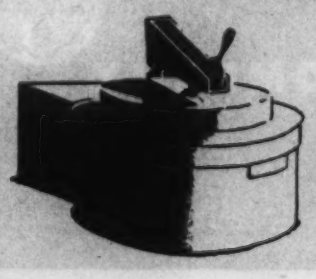
It helps arrive at total costs in advance • Shows recommended department layouts • Tells how to select furnaces of proper size • Gives prices of auxiliary equipment such as tongs, quench tanks, straightening presses, hardness testers, work benches, etc. • Contains loose template pages of furnaces, quench tanks, etc. and graph paper . . . a few seconds of scissor work shows you how your department will look.

To get your copy write or call your nearest Lindberg Engineering Company office or the Lindberg home office at 2451 West Hubbard Street, Chicago 12, Illinois.

Other helps for Heat Treaters. "Heat Treating Hints"—a publication covering the practical side of heat treating with strictly "how to do it" articles. Available on request.

"Heat Treating Hints", two movies, (color and sound) bring to the screen practical articles from the printed "Heat Treating Hints". Ideal for technical associations, plant showings, schools. Write for Bookings.

LINDBERG FURNACES



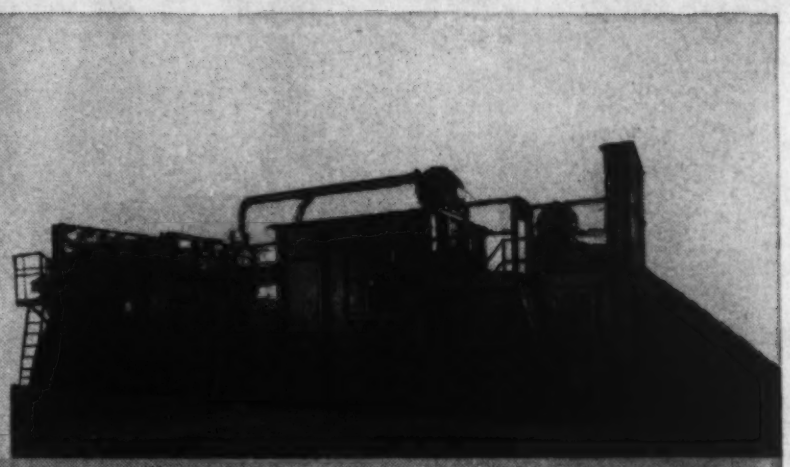
DEPENDABLE PRODUCT CONTROL

Automatically

MAXIMUM FLEXIBILITY of heating rate . . . soaking period . . . product travel . . . and size, shape and weight of product!

Step-by-step control through multi-zone construction with separate heaters, fans and controls for each zone.

Mechanized conveyor and fully automatic control throughout. Forced convection heating recirculated for maximum heating rate and uniformity. Gas or oil fuel.



HAGAN *automatic recirculating* DRAW FURNACE

AUTOMATIC MOVEMENT of product through Hardening Furnace—Automatic Quench—Draw Furnace!

HANDLES irregular sizes, shapes, weights simultaneously or in sequence . . . with uniform results.

For gas, oil or electricity. Requires only a two-man crew! Alloy carriers are not quenched.

HAGAN *continuous automatic* HEAT TREATING FURNACE

HARDENS—DRAWS—STRESS-RELIEVES mixed products of variable sizes, weights and shapes with uniform results.

AUTOMATICALLY follows pre-determined heating, soaking, cooling cycle.

UNIFORM TEMPERATURE CONTROL lengthwise of furnace—accurately checked at up to 10 points in furnace.

SELF-CONTAINED car drive—Super-duty recirculating fans. Gas or oil fired.

HAGAN *automatic* CAR BOTTOM FURNACE

GEORGE J. HAGAN COMPANY

PITTSBURGH, PA.

DETROIT CHICAGO LOS ANGELES SAN FRANCISCO

variety of cutters, are required while the part remains in the fixture or on the table.

High-speed machines have 21 spindle speeds 20 to 1500 rpm. for the No. 2 size, and 18 to 1300 rpm. for the Nos. 3 and 4 sizes, in approximate geometrical progression. Twenty-four feeds, also in geometrical progression, cover a range of 5/16 in. to 60 in. per min. Medium-speed machines have a slightly smaller selection of speeds and feeds, and the upper limits are ⅓ those for high-speed machines.

Vertical types have hydraulic counterbalance for the vertical head. All the types are equipped with built-in vibration damping units—in the overarm of horizontal machines and in the vertical head of vertical machines.

Standard equipment includes motors and controls with all styles of these machines. In addition, vertical machines are equipped with power feed and rapid traverse to the vertical head, and a four position, dial indicated turret stop. Like other power feed units, the vertical head has 16 and 24 different feeds, for the medium-speed and high-speed types, respectively. Feeds range from 5/16 in. to 8 in. per min., and ⅛ in. to 24 in. per min., while the rapid traverse rate is 40 in. per min. for both.

● A new compound manufactured by *Eutectic Welding Alloys Corp.*, 40 Worth St., New York 13, is designed to confine the flow of molten alloys to the limited area upon which the weld is to be applied. This compound protects the parent metal from discoloration at welding temperatures and thus assists in retaining the cleanliness and brightness of the metal. In addition, the possibilities of distortion are greatly lessened, with the temperature being confined to the specific area under consideration.

Die Casting Machines Can Use Single Cavity Dies

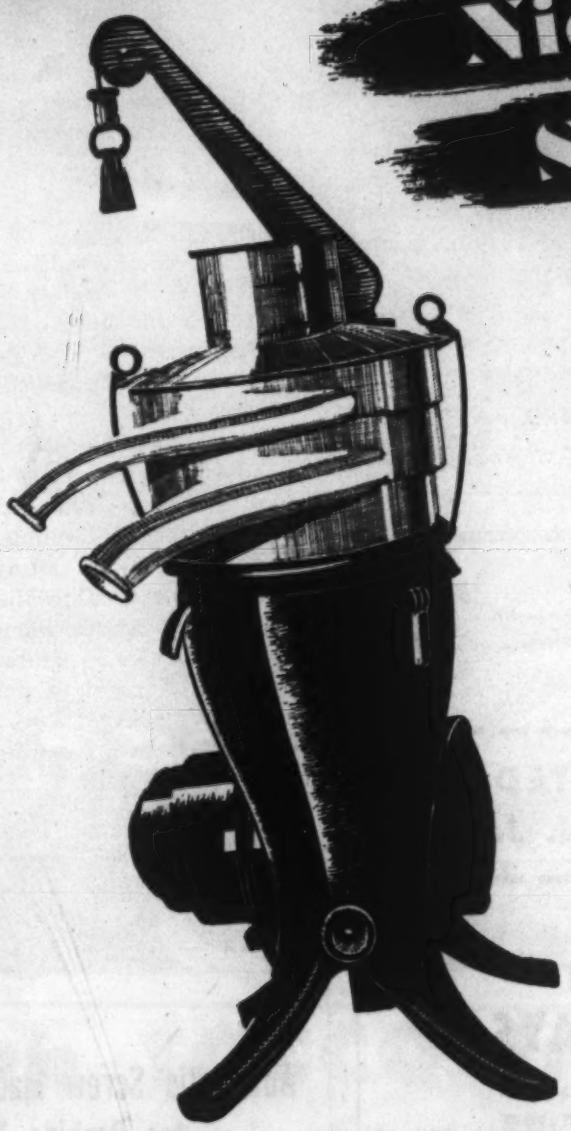
Two new models of die casting machines were brought out recently. One of these is produced by *Light Metal Machinery, Inc.*, Penton Bldg., Cleveland. It is a fully automatic hydraulic type designed for zinc, tin or lead production. Shot capacity is 32 oz. and top speed of the new machine is 720 shots per hr. Other speeds are 520, 340 and 240. Die movement, shot and ejection follow in continuously repetitive cycles.

The machine's higher output enables plants to use single cavity dies and cut die costs. Other advantages listed by the manufacturer include faster die changes, greater dimensional accuracy, smaller floor space needs and lower maintenance cost.

The other model has been introduced by the *DCMT Sales Corp.*, 315 Broadway, New York. It is a small, air-operated die casting machine, designed for quick casting of small

DAIRY PLANT OPERATORS DEMAND....

Nickel Silver Castings for Appearance, Economy, Resistance to Corrosion



Pump casings, impellers, fittings and numerous parts for milk separators and sanitary pumps are cast in Nickel Silver. Users of Nickel Silver for these parts make this wise selection because they know that sanitation .. economy .. corrosion resistance and appearance are combined in this material.

Many state food codes include Nickel Silver alloy requirements in those phases of food processing where these qualities are required .. for experience has proved that Nickel Silver castings reign supreme.

Specify—LAVIN NON-FERROUS INGOT—*Quality*

R. LAVIN & SONS, INC.

Refiners of Brass, Bronze and Aluminum

3426 SOUTH KEDZIE AVENUE : CHICAGO 23, ILLINOIS

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Engelhard THERMOCOUPLES

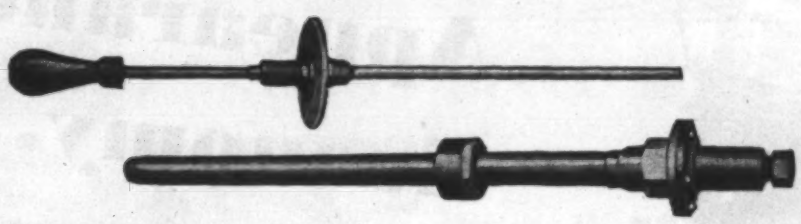
ENGELHARD manufactures a complete line of thermocouples and accessories to meet all requirements . . . . . In addition, ENGELHARD offers thermocouple REPAIR SERVICE

- Rare metal thermoelements (platinum vs. platinum-rhodium) that have served their usefulness are commonly scrapped and replaced by new wire, the scrap value of the old thermoelement applying against the cost. Considering that platinum and its alloys in new wire form are worth approximately four times that, as scrap, the ENGELHARD RECLAIMING PROCESS restores a large part of the old thermoelement to its original condition, equal to new.

- Maintenance engineers easily recognize the tremendous savings effected by almost half or more of the cost of buying a new thermocouple.

Bring your Thermocouple problems to ENGELHARD

48 HOUR REPAIR SERVICE



CHARLES ENGELHARD, INCORPORATED
850 Passaic Ave. • East Newark, N. J.

LENAPE LOW COST TYPE R MANWAYS

LENAPE MANWAYS ARE PRODUCED IN STEEL, AND A VARIETY OF STAINLESS COMPOSITIONS

Type "R" Manway

Type "R" Nozzle with Cover

Lenape Type R Manways offer decided cost reductions in comparison with American Standard Manways of similar rating. Produced to meet ASME Code requirements, these seamless manways are available in heavy type (200 psi) and light type (125 psi) with 16", 18", 20", and 24" openings as standard. Both heavy and light types can be supplied "long" (12" height) or "short" (5" to 8" height) depending upon opening diameter. Slightly curved radius makes for easy entry. Dished covers are available. Swing covers, davits, and similar special details can be supplied for Manway service.

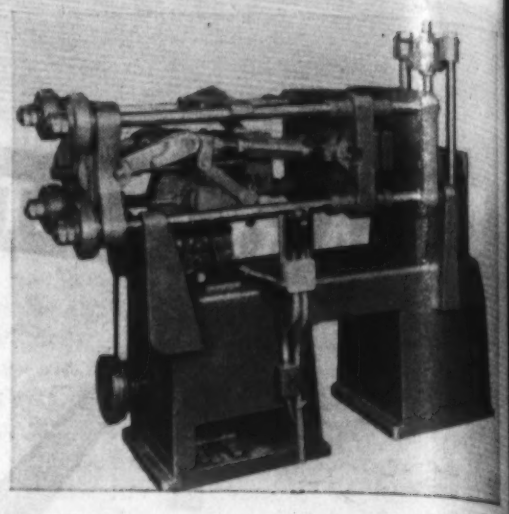
Lenape Type R Nozzles are supplied of heavy or light as above, in short model only. These nozzles are curved to cylindrical diameter or spherical radius as specified.

Quotations will be given our immediate attention — Bulletin 4-61 and current price schedule M-47 will be sent upon request.

LENAPE HYDRAULIC PRESSING AND FORGING CO.

LENAPE HYDRAULIC PRESSING & FORGING CO.
Dept. 102 West Chester, Pa

RED MAN PRODUCTS



This fully automatic hydraulic die casting machine has a 32-oz. shot capacity.

parts in zinc alloy, utilizing single-cavity dies operating at high speed. It can maintain a production rate of 20,000 shots per week.

Features of the machine include optional hand and foot controls and an air system with pilot and ram valves integral. The machine carriage is undercut for downpulls and ejecting large castings. The base plate is adjustable to allow the use of die blocks of any required thickness.

The pot uses hydraulic suction to fill the cylinder. There is a porthole at the base of the pot which allows all the metal in it to be used before refilling becomes necessary.

Automatic Screw Machine Designed for Carbide Tooling

A new multiple spindle automatic screw machine has been announced by the *New Britain-Gridley Div., New Britain Machine Co.,* New Britain, Conn. This new machine is built to handle carbide tooling and has a standard capacity of 2¼ in.

The six cross slides are radial to the center line of the spindle carrier and are 60 deg. apart. This symmetrical radial arrangement gives the same line of forming thrust in each position and allows interchangeability of tool holders among the five forming slides.

Carbide tooling can be applied to this machine because of its over-all weight and ruggedness. Cross slide cams are within the cross slide mountings and, being directly behind the slides, eliminate deflection common with conventional linkage. The increase in chips from high-speed carbide production is taken care of by the wide open tooling area, large chip capacity in the pan, and a chip conveyor.

Tool holders are interchangeable, cross slide cams are easily changed, and attachments are conveniently applied. A universal main tool slide adjustment permits the selecting of any ratio of approach to feed without changing high point, drawback, stops, or total stroke. Stock feed out length is adjusted without changing any cams.

PRODUCTION TRIPLED!
UNIT COST CUT 60%

Nash oil pan showing TOCCO-brazed drain flange. Photo courtesy Nash Motors.

with TOCCO* Induction Heating

Even if your products are entirely different in size and shape TOCCO can probably provide similar cost reductions and production increases for you.

• *Nash Motors,* Kenosha, Wisconsin reports the following benefits from TOCCO Induction brazing of drain flanges to automobile oil pans:

1. PRODUCTION TRIPLED — Using a hand torch, production was only 21 brazed assemblies per hour. TOCCO brazes 75 per hour—357% of former output!

2. COSTS CUT—At the same time TOCCO Induction brazing cuts labor and material costs from $12.75 to $4.90 per hundred—a reduction of 60%, representing a saving of $6.00 every hour.

3. OTHER ADVANTAGES—include a neater, better looking brazed joint, and a complete elimination of leakers and subsequent repair costs.

TOCCO Engineers are glad to help you find applications in your plant where TOCCO Induction Heating would increase your production, cut your costs and improve your products.

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Please send free copy of 60 page book —"Induction Heating"

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STEEL TUBING and BARS

PETERSON STEELS, INC. maintains the largest stock of high carbon-chrome (52100 type) steel, seamless tubing and round bars in the country. More than 200 sizes of tubes from .875" O.D. to 8.231" O.D. Bar stock from .171" round to 7.5" round.

Ring forgings also supplied quickly — any analysis, any size.

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Contains full information on all available sizes, finishes, etc. Write today, on your business letterhead, for your copy.

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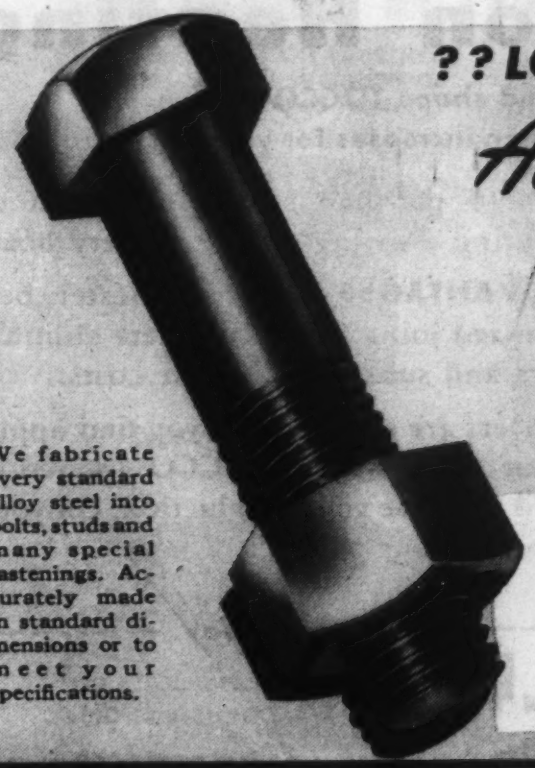
USE HEADED AND THREADED FASTENERS FOR ECONOMY AND RELIABILITY



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Alloy Steel

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We fabricate every standard alloy steel into bolts, studs and many special fastenings. Accurately made in standard dimensions or to meet your specifications.

BETTER BOLTS SINCE 1882—

A full line in carbon steel, heat-treated alloy steels, stainless steel, silicon bronze, brass, bronze, and monel metal.

"THE BOLT MAN"

PAWTUCKET

MANUFACTURING COMPANY

327 Pine Street · Pawtucket, R. I.

THE PLACE TO SOLVE YOUR BOLT PROBLEMS

Carburizing Salt Easily Cleaned from Quenched Parts

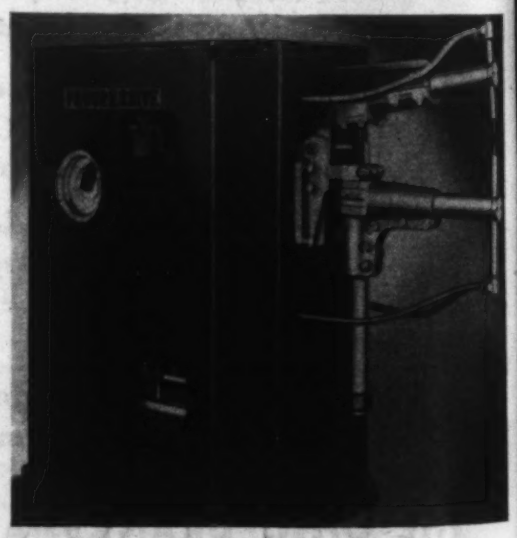
A new carburizing salt which is said to be readily removed from oil quenched parts by immersion in hot water is a development of the *E. F. Houghton & Co.*, Philadelphia. The new product is recommended for case hardening of hard-to-clean parts, at temperatures up to 1575 F. Its lower temperature operation creates less thermal shock and less tendency to warp; the salt washes off readily from threads or crevasses, so that no tumbling or sand blasting is necessary.

This water soluble salt, known as Perliton "W", is also used as a replacement for straight cyanide. The advantages over cyanide claimed by the manufacturer include: time cycles cut in half, harder surface, easier to clean and leaving a cleaner surface, less cyanide breakdown, less fuming, and more pleasant for operators.

Rocker Arm Welder Has Large Arm Adjustment Range

Air-operated rocker arm welders, in both 30- and 50-kva. capacities and with throat depths ranging from 18 to 36 in. for each capacity, have been announced by *Progressive Welder Co.*, 3050 E. Outer Drive, Detroit 12. The front part of the machine, which carries the welding stresses, is of reinforced welded steel construction; the rear part of the machine serves mainly as an enclosure and is provided with removable panels to give access to the interior of the welder.

Some of the features claimed for these welders include: three independent water



This rocker arm resistance welder has three independent cooling circuits for transformer, lower arm and upper arm.

cooling circuits for transformer, lower arm and upper arm; larger range of adjustment of throat opening; optional single operating cylinder or compound retractable stroke cylinder, interchangeable within the machine; transformer direct couple to welding arms and supported from rigid front column of machine; externally accessible heat control; high-speed air valve permitting higher welding speeds.

EXPECT THIS ACCURACY
in the Sleeve Bearings you buy

BEARINGS by Johnson Bronze are precise in every dimension. They are easy to install and they operate efficiently from the start. Achieving this accuracy, consistently, is no accident. Long experience in producing all types of Sleeve Bearings has taught the *correct* speeds, feeds and cuts . . . the proper method of boring . . . the right angle for the chamfer . . . plus the many other fine points that mean the difference between top quality and mediocrity.

Users throughout the nation depend upon Johnson Bronze for such quality. It saves them on assembly costs and improves the serviceability of the finished equipment. Don't be satisfied with less! Since the original cost of Johnson Sleeve Bearings is low, there is no premium charged for this workmanship. Phone the Johnson Branch in your vicinity . . . or write direct for further information.

JOHNSON BRONZE
SLEEVE BEARING HEADQUARTERS
BRANCHES IN 20 INDUSTRIAL CENTERS

JOHNSON BRONZE CO. 769 S. Mill St., New Castle, Pa.

AMAZINGLY DIFFERENT BEARING BRONZE

BEARIUM METAL

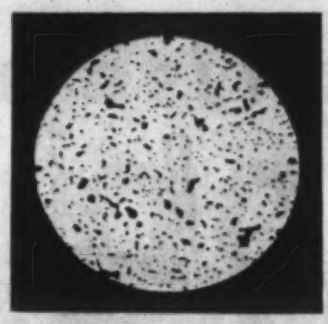
The unique structure of Bearium Metal combines not only the best features of babbitt and bronze, but, in addition, has desirable frictional characteristics that are *exclusive.*

★ It will not melt out like babbitt.

★ It does not score like an ordinary bronze.

★ It definitely puts an end to all problems ordinarily encountered in frictional applications.

Write for full information on this amazing bearing alloy.



BEARIUM METAL *magnified 25 diameters shows lead (black) in microscopic, globular form, uniformly distributed.*

ORDINARY LEADED BRONZE *at 25 diameters shows poor lead distribution, with lead between copper grains.*

BEARIUM

METALS CORP., 270 State Street, Rochester 4, N. Y.

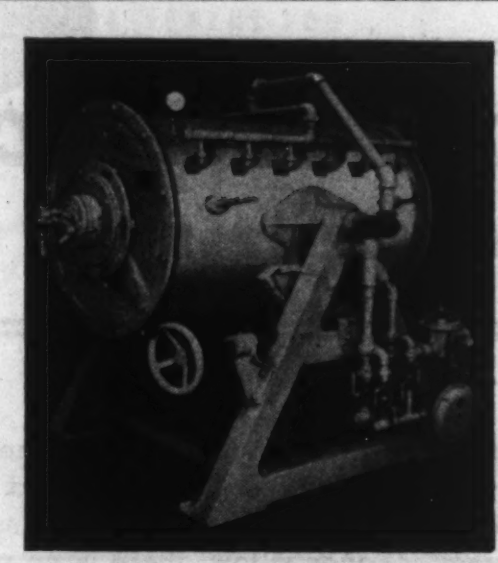
ROTARY GAS CARBURIZERS

A "First" by A.G.F. Co.

Versatility is the outstanding characteristic of AGF Rotary Gas Carburizing Furnaces, which may be used not only for carburizing, but also for clean hardening, normalizing, annealing, and other general or atmospheric work without modification to the furnace of any kind.

Uniform heating of the work is assured by the gentle mixing produced by the rotary action of the retort, which is heated by numerous carefully distributed and balanced gas burners. Carburizing or atmosphere gas is introduced through a simply-designed, trouble-free connection.

Charging and discharging of the work is accomplished by means of a tilting feature, which is power-driven on the larger models. The retort remains within the heat at all times.



The furnace shown above is the latest, improved AGF Rotary Gas Carburizer, batch type, with new maintenance-free roller bearing retort support.

AGF gas carburizing equipment also includes Continuous Rotary Furnaces and Vertical Retort Carburizers. Write for literature.

AMERICAN GAS FURNACE CO.
142 SPRING ST., ELIZABETH, N. J.

News of...

ENGINEERS COMPANIES SOCIETIES

Engineers

Dr. *Henry H. Hausner* has been made a member of the staff, metallurgical research and development laboratories, Sylvania Electric Products, Inc. A research associate and professor in the graduate division at New York University, Dr. Hausner will specialize in powder metallurgy for application to electron tubes, lighting and special products. During the war he developed and patented hermetic seals for electronic equipment widely used in communications apparatus. He received his electrical engineering degree from the University of Vienna in 1925 and his Ph.D. in 1938.

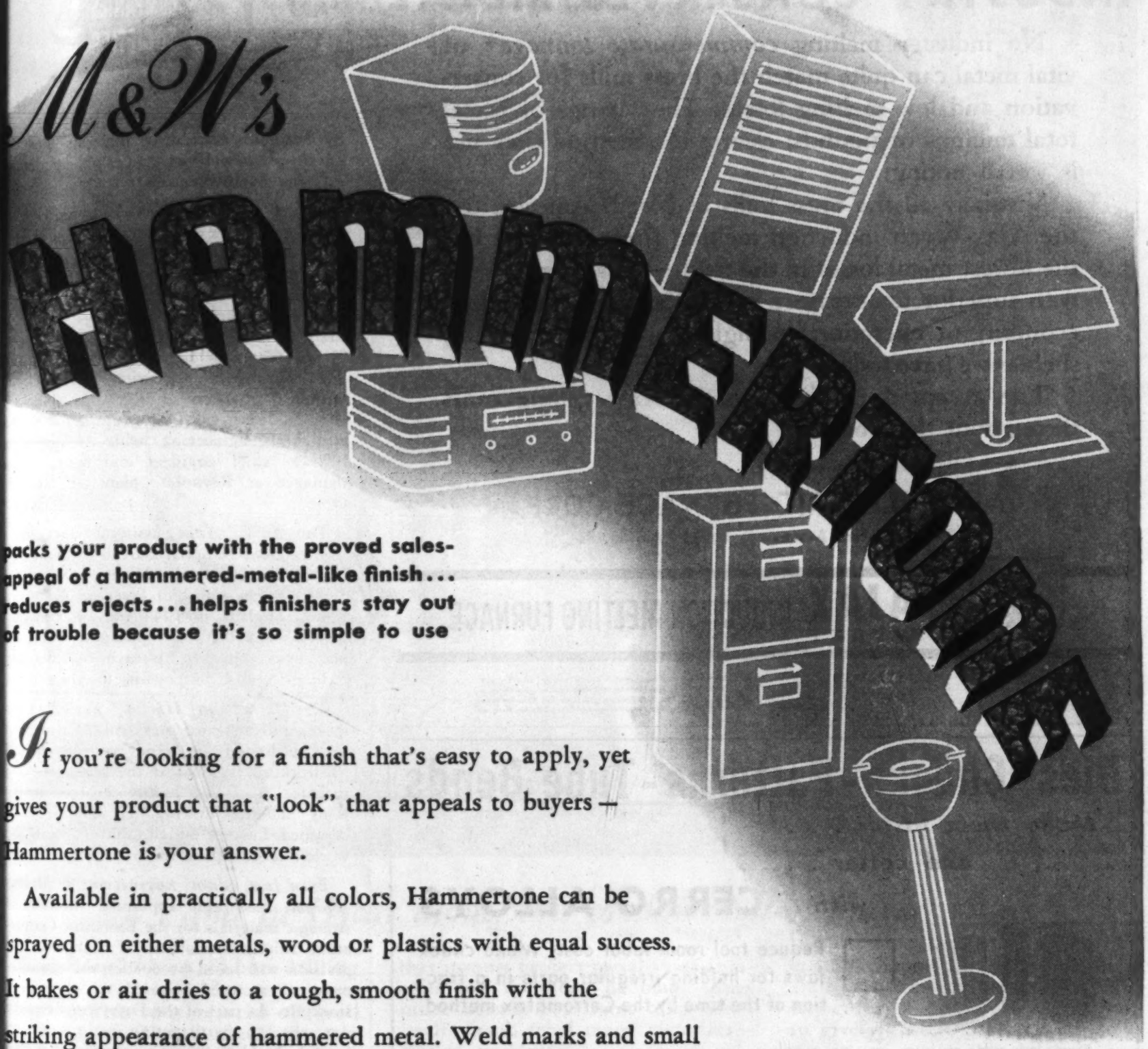
Dr. *R. F. Miller* has been appointed assistant to the vice president, Research & Technology Department, Carnegie-Illinois Steel Corp. He received his doctor's degree from Massachusetts Institute of Technology in 1934 and was then employed as instructor in the Metallurgical Dept. of Yale University, in 1936 joining U. S. Steel at its Kearny, N. J., laboratories. In 1943 he went to Pittsburgh as development engineer in stainless and alloy steels, department of research and technology.

Raymond H. Schaefer has become director of research and development, American Brake Shoe Co., having joined that company in 1940 as an assistant foundry metallurgist for the American Manganese Steel Div., becoming chief metallurgist in charge of metallurgical research and the company's experimental foundry in 1945. He was graduated from Carnegie Institute of Technology in 1934.

R. E. Peterson will supervise the X-ray diffraction laboratory of Permanente's new Kaiser Aluminum Co.'s Metallurgical Research Dept., having formerly been with the Fansteel Metallurgical Corp. The new department will search for new and improved alloys and new aluminum applications. Mr. Peterson has been in charge of various research projects for the U. S. Government at the Watertown and Rock Island arsenals. Mr. Peterson will study the internal structure of new and existing aluminum alloys. The department will determine the structural changes brought about

Sure Cure for Finishing Room Headaches...

M&W's HAMMERTONE



packs your product with the proved sales-appeal of a hammered-metal-like finish... reduces rejects... helps finishers stay out of trouble because it's so simple to use

If you're looking for a finish that's easy to apply, yet gives your product that "look" that appeals to buyers — Hammertone is your answer.

Available in practically all colors, Hammertone can be sprayed on either metals, wood or plastics with equal success. It bakes or air dries to a tough, smooth finish with the striking appearance of hammered metal. Weld marks and small surface defects are hidden by Hammertone, which — in addition to its uniform results in application — reduces rejects to a minimum.

For further information, write for Technical Data Bulletin #115 or ask your M&W representative. Color card is available.

PIONEERS IN PROTECTION

M.&W.Co. 1876

. . . where industry goes with finishing problems

MAAS & WALDSTEIN COMPANY NEWARK 4, NEW JERSEY

Boston 15, Mass. • Chicago 12, Ill. • Los Angeles 34, Calif.
Pacific Coast Division: SMITH-DAVIS CO., 10751 Venice Boulevard, Los Angeles 34
PRODUCERS OF LACQUERS, ENAMELS, SYNTHETICS AND SPECIALIZED PRODUCTION FINISHES

HOW THE WROUGHT BRASS INDUSTRY CONSERVES METAL

No industry melting *commensurate tonnage** of vital metal can quite match the brass mills for conservation and low melting losses. The savings of metal total millions of pounds; clearly the method they use is worth noting:

Virtually all the brass mills in North America use the Ajax-Wyatt induction melting furnace, for it has the lowest metal losses in the field — less than 1% — with superior temperature control and unapproached economy of operation on high production schedules such as we have today.

The accepted melting tool in brass rolling mills throughout the world.

* *Upwards of 5 billion pounds annually.*

AJAX ELECTRIC FURNACE CORP.

1108 Frankford Avenue • Philadelphia 25, Pa.

THE AJAX WYATT INDUCTION MELTING FURNACE

ASSOCIATE COMPANIES: AJAX METAL COMPANY, *Non-Ferrous Ingot Metals and Alloys for Foundry Use*
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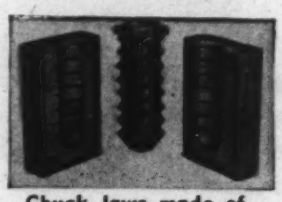
AJAX ELECTRIC COMPANY, INC., *The Ajax-Hultgren Electric Salt Bath Furnace*
AJAX ENGINEERING CORPORATION, *Ajax-Tama-Wyatt Aluminum Melting Induction Furnaces*

Dies - Chucks - Patterns - Tube Bends

Make them faster . . . .
and better . . . .
***with* CERRO ALLOYS**



Chuck Jaws made of Cerromatrix

☐ Reduce tool room labor cost. Make chuck jaws for holding irregular parts in a fraction of the time by the Cerromatrix method.

Duplicate of Master Pattern made with Cerrobase

☐ Speed up production of accurate duplicate patterns for match plates with non-shrinking Cerrobase.

Extrusions and tubes bent with Cerrobend

☐ Thin wall tubing and extruded shapes are readily bent to small radii without buckling; flattening or wrinkles where Cerrobend (melting point 158° F) is used as filler. Readily melts out cleanly in boiling water.

X the operation in which you are interested, and clip this ad to your letterhead. Literature will be forwarded without obligation.

CERRO DE PASCO COPPER CORP.

Dept. 8 — 40 Wall Street — New York 5, N. Y.

News of...

ENGINEERS COMPANIES SOCIETIES

by different fabricating methods and the effects of annealing, tempering, hardening and other heat-treating processes.

M. A. Sievert has been appointed an engineer in the Technical Service Dept., Reynolds Metals Co. He was graduated from the University of Wisconsin in metallurgical engineering, has done research to develop new applications for aluminum, and has designed and made dies of various types. *D. J. Hedgecock* has been made engineering specialist in the wire, rod, bar and structural division of Reynolds. He will promote new uses for aluminum in the structural engineering field. At one time he was chief engineer and acting plant manager at Reynolds' plant at Newark, Ohio.

Dr. *A. V. Astin,* assistant chief, Electronics Div., National Bureau of Standards, has been awarded His Majesty's Medal for Service in the Cause of Freedom. Dr. Astin was in England in 1944 and 1945 in connection with the radio proximity fuze. He has done extensive research on methods, techniques and components for these fuzes.

Charles Lukens Huston, pioneer steelmaker and first vice president, Lukens Steel Co., celebrated his 92nd birthday July 8 by working as usual at the plant. He is a patentee of several highly regarded inventions in steel making. He planned and designed Lukens 4-high, 206-in. mill, the world's largest plate mill.

Evan Just, editor, Engineering & Mining Journal, has been appointed director of strategic materials for the Economic Cooperation Administration at Washington. His division will speed production and procurement of materials needed for the U. S. stockpile. As part of the European Recovery Act, the 16 participating nations are to furnish the U. S. strategic materials that they produce.

Dr. *Robert D. Huntoon,* assistant chief, Atomic Physics Div., National Bureau of Standards, has been presented an achievement award by the Washington Academy of Sciences for 1947. He joined the bureau in 1941 and assisted in the early development of proximity fuzes. At the State University of Iowa he specialized in nuclear physics, receiving his Ph.D. in 1938. He belongs to the American Physical Society and other technical organizations.

Lt.-Gen. *Eugene Reybold,* U. S. Army Engineering Corps. (retired), has been made vice president in charge of operations of Lustron Corp., maker of porcelain enamel all-steel homes. He will be in charge of the engineering, production and ceramics departments. During the war he was chief of the Engineering Corps. and won many distinguished medals.

Edward H. Enberg, Jr. has been placed

"Black Magic" finds an equal...

Photo courtesy Lamb Rubber Co.

. . . and in Hycar alone, this combination of characteristics

"Black Magic" is an oil-base drilling mud, used to counteract earth pressures and to lubricate in oil well drill miles underground. Hycar is a chemically designed rubber made to resist oil.

The man in the picture is showing you a pipe protector made by the Lamb Rubber Company for this operation. It is made of Hycar American Rubber and for very certain reasons. First, the protector has to be stretchable—for a 4-inch protector must pull over a 7-inch joint. But it must be resilient, too, so it hugs the pipe by its own natural strength. But that's not enough! Deep drilling means temperatures of 285 degrees F. and better—so the pipe protector must be resistant to heat. Most important of all, however, is the fact that it must protect metal from abrasion and therefore be many times more abrasion-resistant than metal itself. Lamb tried many materials—settled on Hycar.

So count them: parts made of Hycar are oil-resistant, heat-resistant, abrasion-resistant—resilient, strong and able to stand up under wear. How many materials do you know that combine so many characteristics—and we haven't said yet how Hycar can be compounded so as to be non-staining, easy-processing and take any color of the rainbow you want to give it! We've told you about its use in oil wells only because you, yourself, might get some ideas about parts or products where Hycar American Rubber will do it better. It's used as an adhesive in many fields, as an impregnant for paper and cloth—and for a list of useful items as long as your arm.

Hycar
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American Rubber

We make no finished products from HYCAR—or from any other B. F. Goodrich Chemical Company raw materials. However, we'll be glad to work with you on any special problems or applications. For more information, write B. F. Goodrich Chemical Company, Dept. U-4, Rose Building, Cleveland 15, Ohio. In Canada: Kitchener, Ontario.

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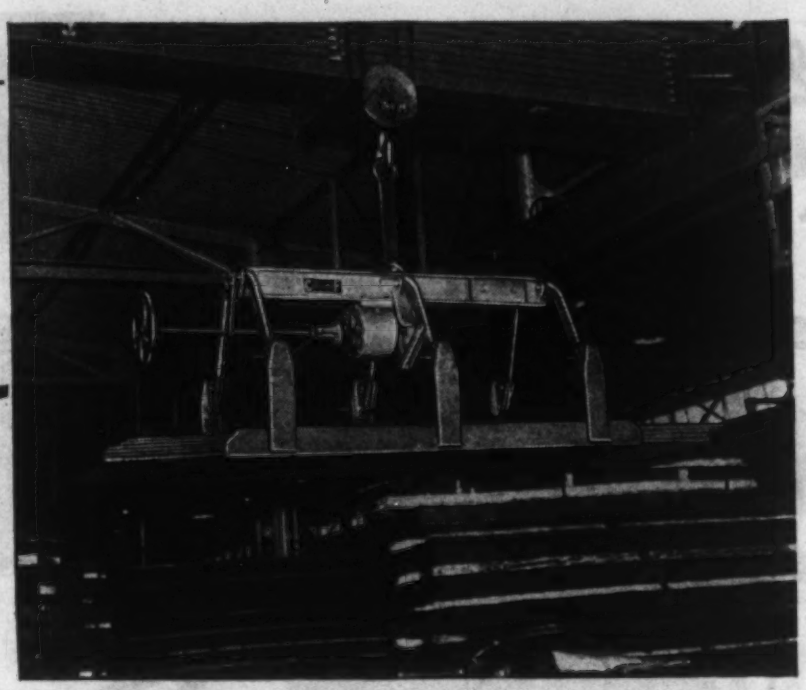
A DIVISION OF THE B. F. GOODRICH COMPANY

GEON polyvinyl materials • HYCAR American rubber • KRISTON thermosetting resins • GOOD-RITE chemicals

Save TIME
Save SHEETS



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Handle loose or bundled sheets with one of these C-F Lifters and you save TIME and SHEETS, because C-F Lifters under one man end control can handle more sheets per load safer, faster and more economically. Tong action grips loads tightly, yet design features like wide bearing surfaces give full protection to stock edges. End control of C-F Lifters permits closer stocking of piles—resulting in more efficient use of storage facilities.

C-F Lifters are available in capacities from 2 to 60 tons or larger, in standard or semi-special designs.

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new inhibitor for bright pickling

• Now available for the first time is a new type of liquid pickling inhibitor—ENTHONE INHIBITOR 9. This new product completely inhibits most non-oxidizing acids—sulphuric, hydrochloric, hydrofluoric and phosphoric. Scale is beautifully and completely removed from steel wire, sheets, rods and finished work, leaving them clean and bright.

Inhibitor 9 is clean and has no odor. It dissolves easily, stops fuming, lowers surface tension for better wetting and displacement of oil films. It is free-rinsing and saves acid by 20% less drag-out plus 99% less attack on steel. *It has every feature required for a perfect inhibitor.*

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News of...

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in charge of all standardization at Kent Cliff Laboratories, Peekskill, N. Y., maker of microhardness testing and allied equipment. *John B. Verrier, Jr.* has been put in charge of sales. Both were for many years in similar capacities with Wilson Mechanical Instrument Co., Inc.

Ralph J. Jess has been promoted to general superintendent of the Steel Improvement & Forge Co. He joined the company in 1940 and was production manager prior to his promotion.

Walter Geist, president, Allis-Chalmers Mfg. Co., Milwaukee, Wis., has been awarded an honorary doctor of engineering degree by the Michigan College of Mining & Technology at Houghton, Mich.

Dr. *Haldon A. Leedy,* acting director, Armour Research Foundation, Illinois Institute of Technology, has been named director. He will administer the widespread industrial research program conducted by his division of Illinois Institute.

Dr. *Philip J. Wilson, Jr.* has left Mellon Institute to join the research and development division of his fellowship donor, the Carnegie-Illinois Steel Corp., as a research associate, where he will supervise the work on process design. Dr. *Joseph H. Wells,* who has been on that fellowship since it was founded, will now head its activities at Mellon Institute.

A. B. Gibson, founder and president, Gibson Electric Co., Pittsburgh, died June 5 at the age of 55 at Pittsburgh. He founded the company of his name in 1933, making electrical contacts by the powder metallurgy process. Under his direction new materials, processing and fabrication methods were developed, resulting in "Gibsiloy." He served as chairman of various committees on electrical contacts and powder metallurgy of the American Society for Testing Materials. He was awarded the honorary degree of doctor of engineering by the Clarkson College of Technology in June, 1947. In earlier days he was awarded degrees in both mechanical and electrical engineering.

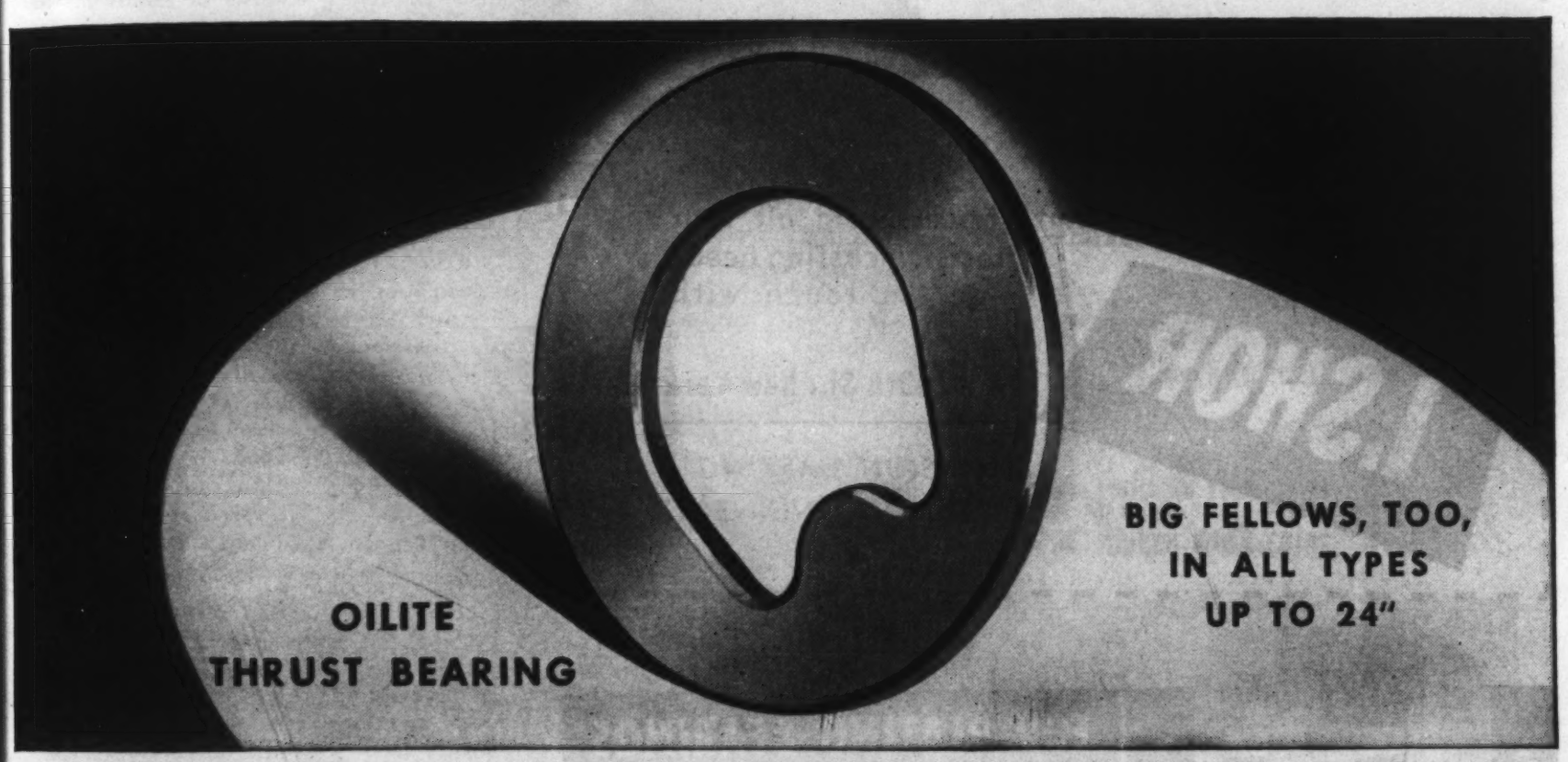
Companies

The General Electric Co. has established a $25,000,000 center at Lynn, Mass., for development, testing and production of aircraft jet engines. Since the war's end $11,000,000 has already been spent for

OILITE

OIL CUSHION — HEAVY DUTY

BEARINGS



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OILITE—The HEAVY DUTY OIL CUSHION BEARING with Reserve Capacity.
OILITE operates under the principles of hydraulics.
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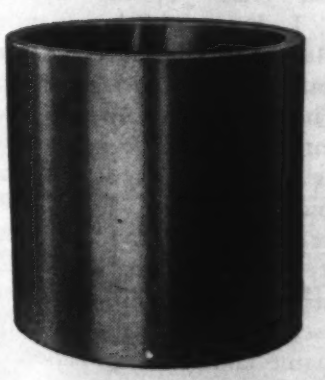

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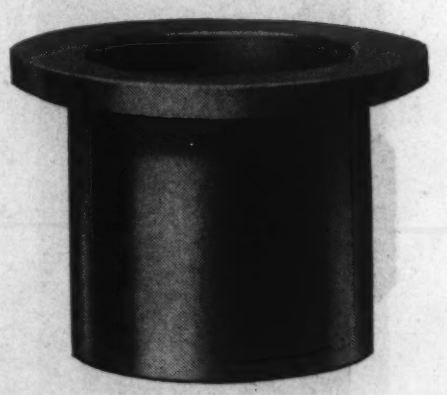
OTHER ADVANTAGES INCLUDE:

- Every bearing is an engineered product.
- Oilite bearings can be assembled and the bore finished simultaneously—reducing costs.
- Ferrous and non-ferrous, oil cushion bearings.
- No blow holes or other flaws.
- Production tools on hand for over 18,000 different types and sizes.
- Large research and engineering staff.
- Complete engineering service.
- Greater plant facilities.
- Over twenty (20) years of powder metal know-how.
- Representation in every state and Canada.
- Oilite bearings are not expensive.



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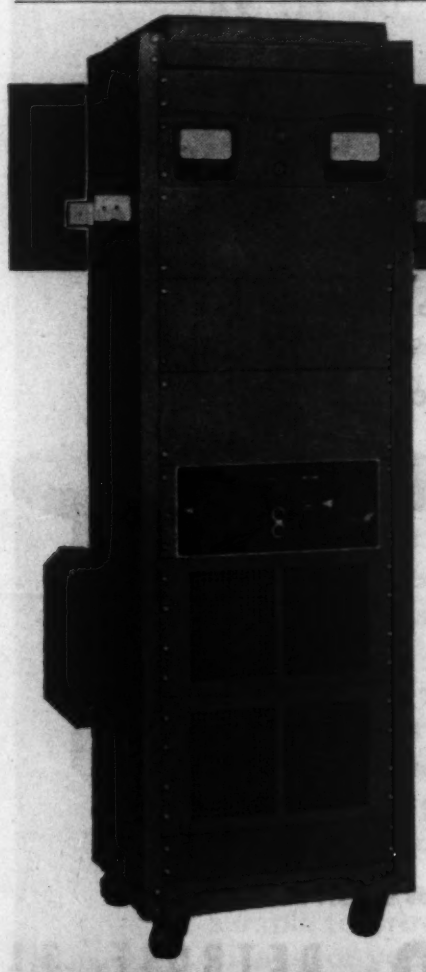

FOR PLATING BEARINGS or other parts

The Green Electric line of Rectifiers, for supplying D.C. power, includes over two hundred standard types ranging from 6 volts to 60 volts and from 25 amperes to 5,000 amperes.

In addition Green Electric have engineered several thousand custom-built units for particular applications or unusual plant layouts.

Green Electric, established since 1892, specialize *exclusively* in rectifier equipment.

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new facilities, including a huge new test laboratory for jet engine components. The new laboratory consists of stands for full power testing of compressor, combustion chamber and turbine elements of actual engines and model testing of single and multi-stage compressor elements. The company is now producing an engine with 5000-lb. thrust, which will later be extended to 6000 lb. The G.E. plant will be the largest of its kind in the world.

The *B. F. Goodrich Co.* has opened with ceremonies its new, multi-million dollar research center at Brecksville, Ohio, which the president of the company describes as the "most complete industrial workshop of science" now existing. The technicians will probe into the mysteries of crude and man-made rubber, and into chemicals, plastics, agriculture, horticulture and application of nuclear energy to rubber manufacturer. The same company established the first research laboratory in the rubber industry in 1895.

The Greer Steel Co., Dover, Ohio, has become the eighth steel company to be licensed to manufacture "Cor-Ten," corrosion-resisting, high strength, low-alloy steel, developed by the Carnegie-Illinois Steel Corp.

An order for $1,206,445 work of porcelain enamel, the largest in the history of the industry, has been placed with the Chicago Vitreous Enamel Product Co. by the *Lustron Corp.*, builder of porcelain enamel steel homes. Lustron's schedule calls for 15,000 homes in 1948 and 45,000 in 1949.

The *United States Testing Co., Inc.*, Hoboken, N. J., has established a proving ground at Miami for actual exposures of engineering materials to sun, wind, rain and salt water. These actual weather exposures will augment simulated conditions exposures in its Hoboken laboratories, where the company maintains Fade-Ometers, Weatherometers, oxygen and air bombs, high humidity chambers, salt air chambers and circulated air ovens with many types of controls. These facilities are used widely in textile and paint color determinations.

A new multi-million dollar chemical plant for the manufacture of silicone materials has been completed at Waterford, N. Y., by the Chemical Dept., *General Electric Co.* The products are processed in the form of rubber, oils, grease, resins and water-repellents.

Martin Quaid Co., alloy metal fabricator, has moved to a new location, 1815 W. Sedgley Ave., Philadelphia. The company specializes in the production and fabrication

(Continued on page 138)

These pictures SHOW you...

This bulletin TELLS you...

Ransome 12 Ton Welding Positioner at Marion Power Shovel Co., Marion, O. Gear being welded and preheated at same time.

Ransome 2500 lb. Welding Positioner being used with automatic welding head at Wooldridge Mfg. Co., Sunnyvale, California.

how Ransome "DOWNHAND" welding positioning

- ups production 50%
- cuts work in half
- gives better, neater welds
- reduces rod waste 5-7%
- makes work safer

RANSOME POSITIONERS . . . constant or variable speed rotation through full 360° in either direction . . . wide welding speed range . . . 135° tilting hand or motorized as required . . . permits Downhand welding at any angle . . . capacities 100 lb. to 40,000 lb.

RANSOME TURNING ROLLS . . . standard capacities 4½ to 45 tons, stationary or self-propelled, also larger sizes available.

Ransome

50% PRODUCTION UP LABOR COSTS DOWN

WELDING POSITIONERS

INDUSTRIAL DIVISION

RANSOME MACHINERY COMPANY

A SUBSIDIARY OF WORTHINGTON PUMP AND MACHINERY CORPORATION

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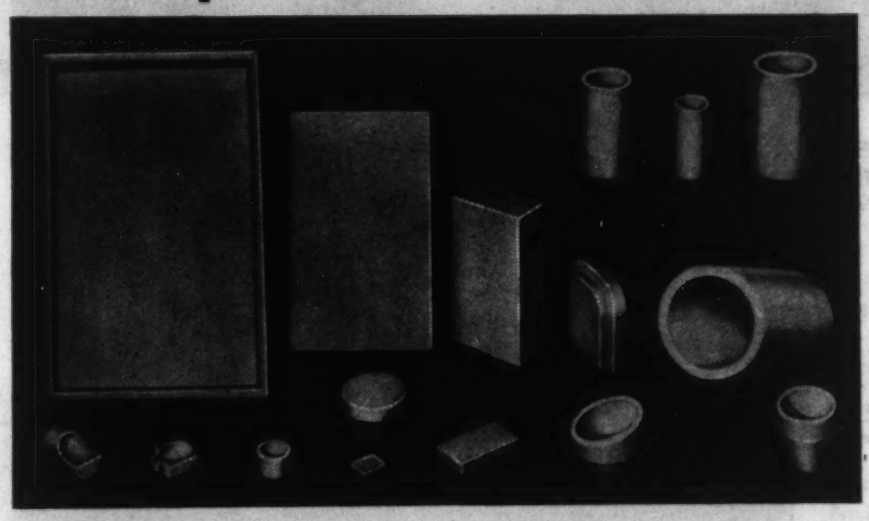
when the heat's *ON and OFF* . . . use dependable WESGO refractories



These many WESGO super refractory shapes serve industry in the form of

- **powdered metal sintering trays**
- **furnace crucibles**
- **gas turbine nozzles**
- **brazing trays, and others**

For use where the ability of the material to withstand thermal shock is of prime importance.

Have you a ceramic problem?

We specialize in the manufacture of special shapes for those applications where a ceramic body is subjected to extremely high thermal shock.

Make this test — we'll supply a specimen

Heat a Wesgo crucible up to 2000F as rapidly as possible— then plunge it immediately into cold water. It won't crack or spall or otherwise suffer damage!

Write for quotations and samples, outlining service conditions. Descriptive booklet on request.

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News of...

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of industrial architectural and special shapes in stainless steel, aluminum, brass, bronze, copper, steel, alloys and other metals.

The *International Nickel Co., Inc.* recently gave a demonstration of precision investment castings, popularly known as the "lost wax" process, at Bayonne, N. J. It was stated by the exhibitors that alloys ranged in nickel content from 2 or 3% up to 96%. The principal industries using these castings are aircraft engine makers, chemical equipment plants, laundry machinery makers, and dispensing and coin machines.

A 10-man French industrial mission has been inspecting United States industrial plants, including the Philadelphia plants of *SKF Industries, Inc.*

The *Fort Pitt Bridge Works* has entered the pipe fabrication field at its Canonsburg, Pa., works through utilization of a 36-ft. press, powered with six 500-ton jacks. A typical product is 10¾-in. O.D. pipe with ¼-in. wall and welded couplings for surface casing.

A new glass section has been added to the laboratory facilities of *Sam Tour & Co., Inc.*, 44 Trinity Place, New York, engineers, metallurgists and consultants. It will specialize in glass failures.

What is claimed to be America's oldest gas turbine research group, *Northrop-Hendy Co.*, Hawthorne, Calif., is being set up as a completely independent engine development facility to be known as the Turbodyne Corp. It has developed a 10,000-h.p. gas turbine for aircraft which turns propellers instead of depending on jet thrust. Sponsors claim their engine means greater distance at high speeds on less fuel than with a jet engine.

The *Harrington & King Perforating Co.*, Chicago, incorporated in 1883 and performing industrial and ornamental perforating of metals and other materials, announced the retirement of J. M. Fuller as president after 62 years of service with the company. He is succeeded by Foye P. Hutchinson.

Wolverine Tube Div., *Calumet & Hecla Consolidated Copper Co., Inc.*, has completed a new 16-mm. movie, "Quality Control—From Ore to Finished Product." This 40-min. production, in full color and complete with sound track, follows copper ore, deep in the ground, to seamless, nonferrous tubing and to typical end applications.

The *U. S. Atomic Energy Commission* will establish a chemical laboratory in New Brunswick, N. J., at a cost of over $1,000,000, where it will process uranium, beryllium, and other ores. It will occupy a plant

ENGINEERED IN PLASTICS BY GENERAL ELECTRIC

Plastics improve your circulation

●Now plastics help to ventilate the kitchen. This rugged propeller is molded in one piece by General Electric for the American Blower Corporation's new Aeropel home ventilator. It is *molded in balance*. And for this Aeropel unit General Electric also molds a sparkling white plastics grille —an attractive housing that adds beauty to any room.

Whatever *you* make, from fans to ferryboats, it is likely that General Electric's complete plastics service can help you to cut production costs or improve your product . . . or both.

Equipped to design, engineer and mold the *right* plastics parts for your requirements, General Electric invites the tough problems and the hard jobs.

If top quality is important in the plastics parts you buy, it will be worth your while to get acquainted with G-E's *complete* plastics service. Phone or drop a line to our nearest sales office. Or write for information and your free copy of the interesting booklet, "Problems and Solutions in Plastics." Plastics Division, Chemical Department, General Electric Company, 1 Plastics Avenue, Pittsfield, Mass.

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BACKED BY 53 YEARS OF EXPERIENCE. We've been designing and manufacturing plastics products ever since 1894. G-E research works continually to develop new materials, new processes, new applications.

NO. 1 PLASTICS AVENUE—complete plastics service—engineering, design and mold-making. Our own industrial designers and engineers, working together, create plastics parts that are both scientifically sound and good-looking. Our own toolrooms are manned by skilled craftsmen—average precision mold experience, over 13 years.

ALL TYPES OF PLASTICS. Facilities for compression, injection, transfer and cold molding . . . for high and low pressure laminating . . . for fabricating. G-E Quality Control—a by-word in industry, means as many as 160 inspections and analyses for one plastics part.

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GENERAL ELECTRIC PLASTICS FACTORIES ARE LOCATED IN SCRANTON, PA., MERIDEN, CONN., COSHOCTON, OHIO, DECATUR, ILL., TAUNTON AND PITTSFIELD, MASS.

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—Chip

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built by the Navy during the war to manufacture pumps.

The *Monsanto Chemical Co.* has purchased a surplus synthetic rubber plant at Springfield, Mass., from the War Assets Administration for $169,500.

Harold C. R. Carlson announces a new office of the *Carlson Co.* at 277 Broadway, New York 7, to provide design and consultation services for manufacturers, engineers and inventors, specializing in design of springs and mechanical products.

The $18,500,000 expansion program of the Fontana steel plant of *Kaiser Co., Inc.* will provide for hot-rolled sheets, electric weld pipe, and an additional open-hearth furnace.

The general offices of *Ceco Steel Products Corp.* have been moved to a new office building at 5601 W. 26th St., Chicago 50.

Societies

The *American Foundrymen's Assn.*, 52 years old, has voted to change its name to *American Foundrymen's Society* because the new name is more descriptive of its functions and conforms to the general practice in the names of other large, recognized technical and scientific groups.

Surface chemistry in various aspects will be covered in the fourth annual Cleveland symposium at the Hotel Carter Sept. 25 under the auspices of the *American Chemical Society, American Institute of Chemical Engineers* and *Electrochemical Society*. Among topics of formal papers are: crystal structure and surface behavior, industrial catalysts, surface reactions of anodic magnesium, phosphate coating of metal, principles of powder metallurgy, and organosols and plastisols.

The *Engineering Foundation* will sponsor 14 research projects for the year beginning in October, 1948, in such fields as hydraulics, metal cutting, alloys of iron, properties of gases and their mixtures, riveted and bolted structural joints, reinforced concrete, welding and properties of metals at different temperatures. Research is carried on at universities and engineering plants.

The *American Welding Society* has awarded $700 to students and editors of college publications for authorship and

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1. *Consult* the Milford free engineering service

2. *Choose* one of 15 basic Milford rivet setting machines — offering unlimited versatility.

3. *Select* exactly the right semi-tubular or split rivet or cold-headed fastener from Milford's complete line.

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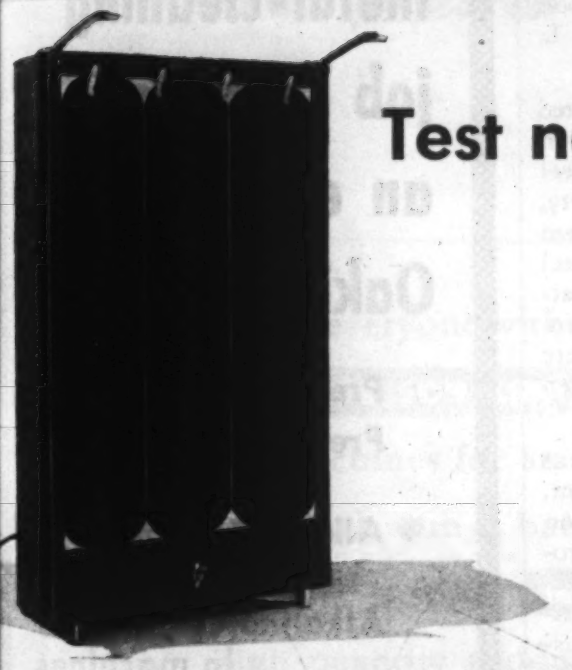
Improve over-all welding quality . . .

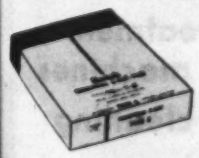
Constant improvement in over-all welding quality is due largely to the welder's adoption of new and proved practices and technics. In this, radiography is contributing importantly by providing records that help determine good practice by showing the internal conditions of the weld without destructive testing.



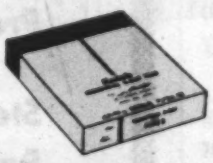
Test non-destructively with radiography . . .

Radiographic examination of welds helps develop sound welding technics faster . . . helps determine the soundness of the weld itself. It assures that the weldment has satisfactory penetration, is well fused, and is free from objectionable inclusions, porosity, and other irregularities. Often the information obtained from radiographs of the first job will decide welding procedure on an entire production run.

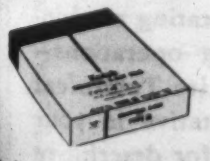
For maximum radiographic visibility— use Kodak Industrial X-ray Films . . .



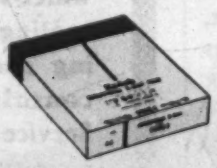
ak Industrial X-ray , TYPE A . . . for x-ray gamma-ray work in sec- where fine grain and contrast are desirable aximum sensitivity at erate exposure times.



Kodak Industrial X-ray Film, TYPE K . . . designed for gamma-ray and x-ray radiography of heavy steel parts, and of lighter parts at limited voltages where high film speed is needed.



ak Industrial X-ray n, TYPE M . . . first ce in critical inspection ght alloys, thin steel at erate voltages, and y alloy parts with on-volt equipment.



Kodak Industrial X-ray Film, TYPE F . . . with calcium tungstate screens—primarily for radiography of heavy steel parts. For the fastest possible radiographic procedure.

They provide the high radiographic sensitivity—the combination of speed, contrast, and fine grain required for the detail visibility you need in critical examination of welds.

For complete information on the types best adapted to your job, see your local X-ray dealer or write to

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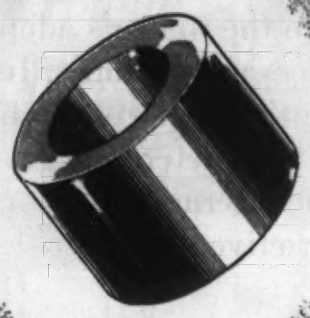

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SELF-LUBRICATING ● EXTREMELY DURABLE ● CONSTANT CO-EFFICIENT OF FRICTION ● OPERATES DRY — OR SUBMERGED IN WATER, GASOLINE OR CORROSIVE LIQUIDS ● APPLICABLE OVER A WIDE TEMPERATURE RANGE — even where oil solidifies or carbonizes ● EXCELLENT AS A CURRENT-CARRYING BEARING.

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News of...

ENGINEERS COMPANIES SOCIETIES

publication. Winners were: Robert Baysinger, writing on "Brief Review of Failures in Welded Vessels" in *"Ohio State Engineer,"* and Miss Rosella Horine, editor; Mark J. Orelup, "Spot Welding of Carbon Steels," in *"Rose Technic,"* and Orville L. Stone, its editor.

The *Electric Metal Makers Guild* elected as president at their 16th annual meeting in June A. J. Scheid, Jr., Columbia Tool Steel Co., Chicago Heights. Dr. C. H. Herty, Jr., assistant to the vice president, Bethlehem Steel Co., talked on fundamentals in steel melting; C. E. Sims, assistant director, Battelle Memorial Institute, spoke on hydrogen and nitrogen contents of steel. There was an open forum on the use of oxygen in electric furnace steel making.

The *Drop Forging Assn.* has elected as president Ralph A. Mitchell, vice president, Pittsburgh Forgings Co. The association comprises 115 forging companies that produce stress parts with load-bearing characteristics used in mass transportation, agricultural and other metal-fabricating industries.

Richard L. Templin was elected president, *American Society for Testing Materials,* at the annual meeting in Detroit in late June. He is assistant director of research and chief engineer of tests, Aluminum Co. of America. He has developed many of the testing methods used in the inspection and quality control of aluminum products. He has won several medals and has authored many papers and reports.

James M. Todd, New Orleans consulting engineer, has been nominated for president by the *American Society of Mechanical Engineers.* His engineering connections have included Penick & Ford, Ltd., Cedar Rapids, Iowa, and A. M. Lockett & Co., mechanical engineering contractors of New Orleans.

The *Malleable Founders Society* has presented Robert R. Fauntleroy, president, Moline Malleable Iron Co., with the Charles H. McCrea medal for the person "rendering the most outstanding service to the malleable iron industry." The new president of the society is Collins L. Carter, president, Albion Malleable Iron Co., Albion, Mich. The outgoing president, Wilson H. Moriarty, vice president, National Malleable & Steel Castings Co., Cleveland, stated that the shortage of steel scrap will become even more stringent unless we bring back metal we've exported previously. For 50 years we have exported finished ferrous goods without receiving any scrap in return. During the war alone we exported 120,000,000 tons. Industries are now paying $20 a ton premium for scrap, he said.

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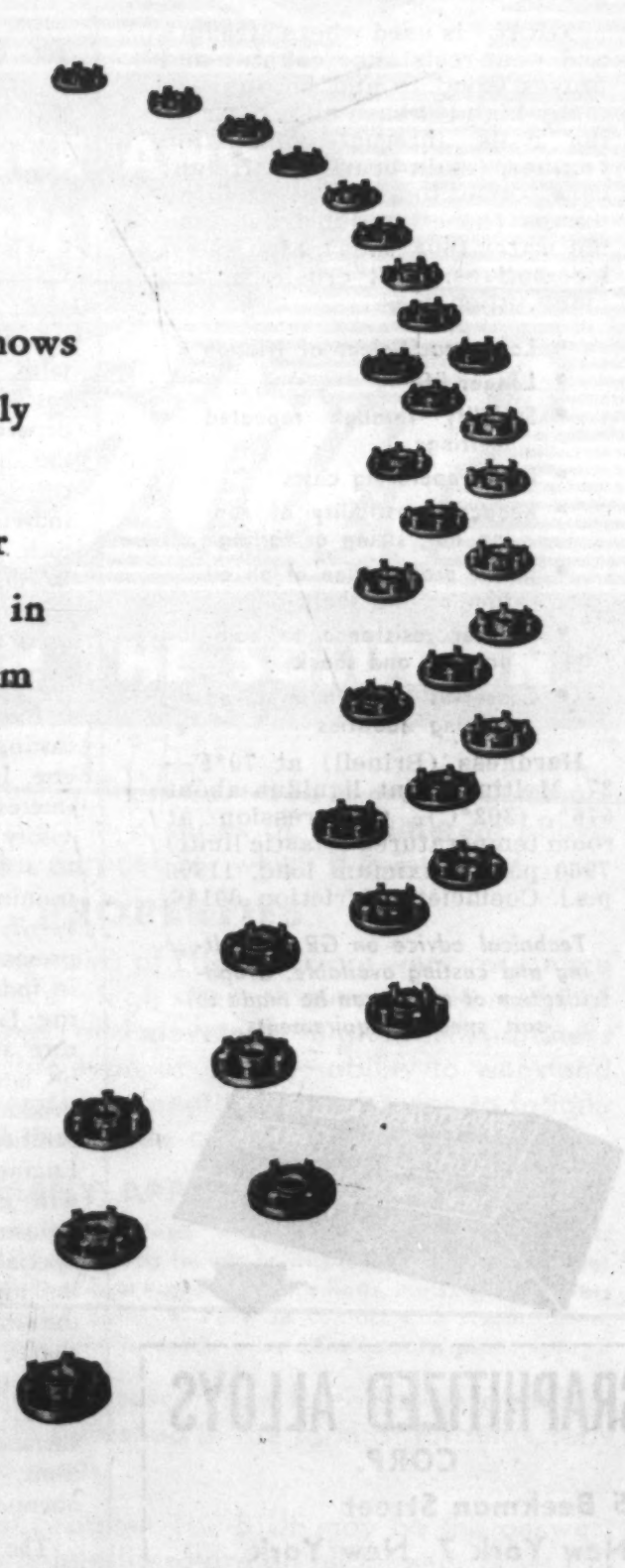

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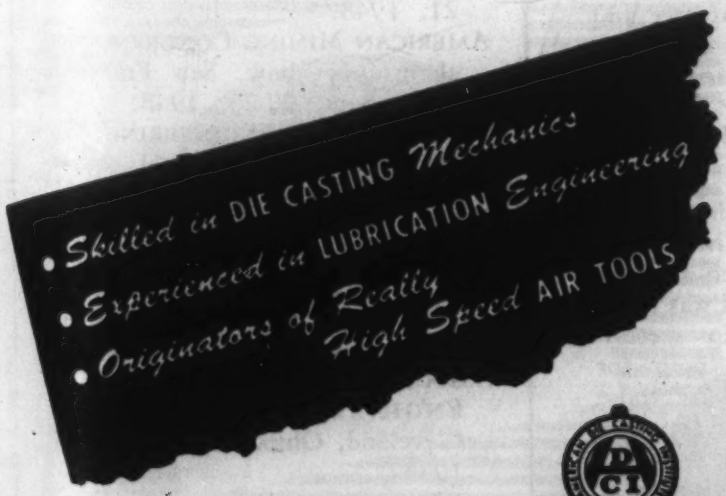

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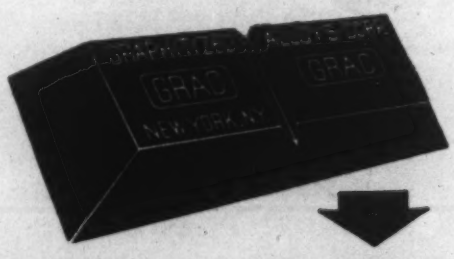

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special machinery will be featured on a bigger scale at the third plastics exposition of the *Society of the Plastics Industry, Inc.*, Sept. 27-Oct. 1, at the Grand Central Palace, New York. Various steps and stages of manufacture will be shown from the raw material to consumer product. Especially interesting will be new machine tool models, some in full size in action and others in miniature.

The *Gray Iron Founders' Society*, Cleveland, has published a Cost Dictionary to assist foundry clerical personnel in classifying all items of foundry expense. It contains more than 200 items of foundry cost, listed alphabetically, followed by the department and title of the account to which the item should be charged. Opposite each cost item is a blank space for use of individual foundries. Copies sell for $1 each. The Society has been campaigning at Washington for a more equitable distribution of scarce pig iron and has urged users to employ larger percentages of scrap, even at premium prices, to conserve iron.

Purdue University will hold a metals casting conference on its campus at Lafayette, Ind., Nov. 4 and 5, covering subjects interesting to top management and supervisory personnel. Purdue will also be host to a conference on industrial and business training Sept. 29 and 30. *New York University* will give a course in plastics, its present and potential uses and application in industry, starting Oct. 6, 1948 and ending Jan. 26, 1949. There will be 15 lecture and discussion sessions at which will be analyzed the characteristics of plastics products, with major emphasis on opportunities for increased uses in industry. The Engineering School of *Columbia University* will give a 5-day training conference in industrial experimentation Sept. 14-18. Specialists from industry will speak. Among the topics will be: nature of problems in industrial experimentation; role of control charts, correlation, analysis of variance and their interrelation in the design of experiment; assumptions underlying analysis of variance, one-way and two-way classifications; Latin squares, factorial designs, sequential methods.

The 1948 Daniel Guggenheim medal, given for notable achievements in the advancement of aeronautics, has been awarded to Leroy R. Grumman. The award was made for "outstanding achievement in successfully advancing aircraft design both for Naval and peacetime use." Among those choosing the recipient were: The *American Society of Mechanical Engineers, Society of Automotive Engineers* and *Institute of Aeronautical Sciences.*

The *American Society of Body Engineers, Inc.* will hold its annual convention Nov. 3-5 at the Rackham Memorial Bldg., Detroit. There will be eight general sessions and an industrial exhibit of body materials, parts and body hardware, many of which indicate future design trends.

The jury of award, Western New York section, *American Chemical Society*, has awarded the Jacob F. Schoellkopf medal for 1948 to Marvin J. Udy, whose better known achievement is the development of the process for cadmium plating, the patents for which formed the basis for the formation of the Udylite Corp., 1651 E. Grand Blvd., Detroit.

Meetings and Expositions

SOCIETY OF AUTOMOTIVE ENGINEERS, West Coast meeting. San Francisco, Calif. Aug. 18-20, 1948.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, Pacific general meeting. Spokane, Wash. Aug. 24-27, 1948.

AMERICAN CHEMICAL SOCIETY, national meeting. Washington, D. C. Aug. 30-Sept. 3, 1948.

AMERICAN CHEMICAL SOCIETY, national meeting. St. Louis, Mo. Sept. 6-10, 1948.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting. Portland, Ore. Sept. 7-9, 1948.

SOCIETY OF AUTOMOTIVE ENGINEERS, tractor and diesel engine meeting. Milwaukee, Wis. Sept. 7-9, 1948.

AMERICAN CHEMICAL SOCIETY, national meeting. Portland, Ore. Sept. 13-17, 1948.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Instruments & Regulators Div. meeting. Philadelphia, Pa. Sept. 13-17, 1948.

INSTRUMENT SOCIETY OF AMERICA, annual meeting. Philadelphia, Pa. Sept. 13-17, 1948.

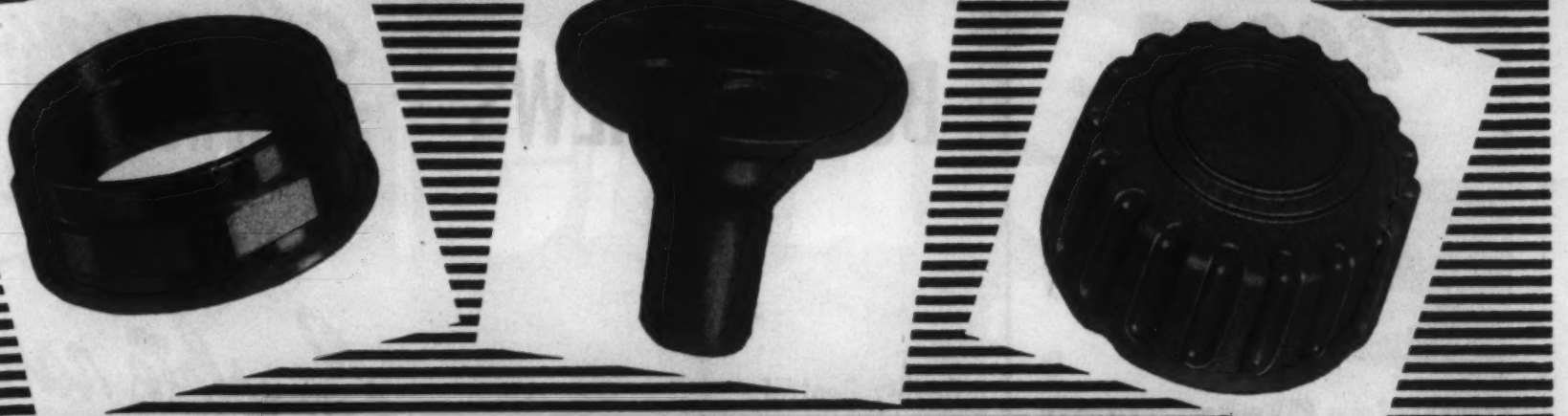
AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Aviation Div. meeting. Dayton, Ohio. Sept. 20-21, 1948.

AMERICAN MINING CONGRESS, metal mining show. San Francisco, Calif. Sept. 20-23, 1948.

ILLUMINATING ENGINEERING SOCIETY, national technical conference. Boston, Mass. Sept. 20-24, 1948.

SOCIETY OF THE PLASTICS INDUSTRY, national plastics exposition. New York, N. Y. Sept. 27-Oct. 1, 1948.

ASSOCIATION OF IRON & STEEL ENGINEERS, annual meeting. Cleveland, Ohio. Sept. 28-Oct. 1, 1948.



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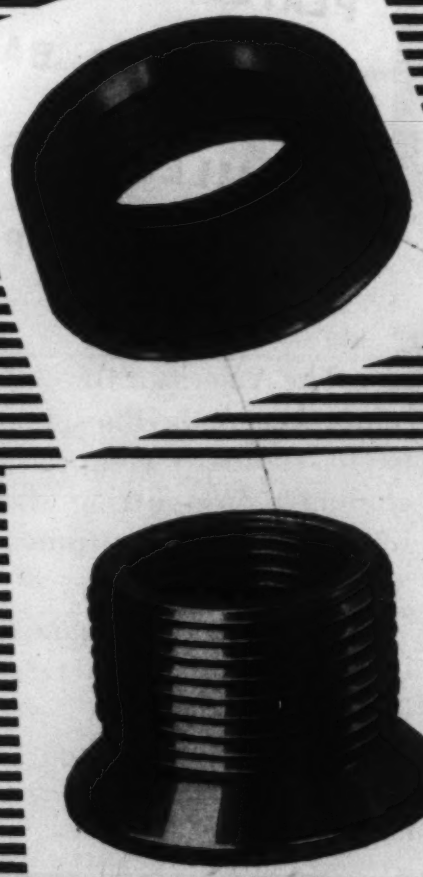

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BOOK REVIEWS

Quality Control

QUALITY CONTROL METHODS. *By Clifford W. Kennedy. Published by Prentice-Hall, Inc., New York, 1948. Cloth, 6¼ x 9¼ in., 243 pages. Price $4.75.* Contains elementary information needed for a complete understanding and as background for the more technical and involved practices that modern quality control requires in order to reach and maintain its full effectiveness. Theoretical and practical data are offered so that a well-balanced knowledge of this subject from both viewpoints can be obtained.

The topics covered are: acceptance sampling; batch control — per cent defective methods; distributions and the standard deviation; average and range; and guide to the administration of methods.

Other New Books

1947 SUPPLEMENTS TO A.S.T.M. STANDARDS 1946. PART I-A, METALS, 350 PAGES; PART I-B, NONFERROUS METALS, 334 PAGES; PART II, NONMETALLIC MATERIALS (CONSTRUCTIONAL), 480 PAGES; PART III-A, NONMETALLIC MATERIALS, 454 PAGES; PART III-B, NONMETALLIC MATERIALS, 322 PAGES. *Published by American Society for Testing Materials, Philadelphia, 1948. Heavy paper, 6 x 9 in. Price $4.00 each.* These supplements, together with the 1946 Book of Standards, give a complete set of A.S.T.M. specifications and tests, excepting the chemical analysis of metals, which are in a special volume.

ELECTROLYTIC POLISHING OF METALLIC SURFACES AND ITS APPLICATIONS—VOL. I. (LE POLISSAGE ELECTROLYTIQUE DES SURFACES METALLIQUES ET SES APPLICATIONS). *By P. A. Jacquet. Published by Editions Metaux, 32 Rue du Marechal Joffre, Saint-Germain-en-Laye (S.-&-O.), France, 1948. Cloth, 8½ x 11 in., 359 pages. Price 3600 Fr. In French.* This volume covers aluminum, magnesium and light alloys; presumably other volumes will cover other base metals.

TRANSACTIONS OF THE AMERICAN FOUNDRYMEN'S ASSOCIATION. VOL. 55. *Published by the American Foundrymen's Assn., Chicago, 1948. Paper, 8¼ x 11¼ in., 658 pages. Price $4.00 to members; $15.00 to non-members.* Contains summary of proceedings of the 51st annual meeting held in Detroit, Apr. 28th to May 1st, 1947. Reports of officers, the first Charles Edgar Hoyt annual lecture (given by Dr. James T. Mackenzie), and over 60 technical papers and committee reports are included.

TRANSACTIONS OF THE ELECTROCHEMICAL SOCIETY. VOL. 91. *Published by the Electrochemical Society, Inc., New York, 1947. Cloth, 6 x 9 in., 723 pages. Price $6.50.* Includes proceedings of the 91st general meeting of the Electrochemical Society, held in Louisville, Ky., April 9 to 12th, 1947, annual technical reports and over 30 technical papers (four of which were presented at the Toronto Convention in October, 1946).

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